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BIOPHYSICAL RESEARCH

DESIGN OF THE EMISSION INVENTORY: EMISSION INVENTORY OF SULPHUR OXIDES AND NITROGEN OXIDES IN ALBERTA

by:

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Calgary, Alberta, Canada

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Emission Inventory

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***Detailed data compilations, of technical interest.**

EMISSION INVENTORY OF SULPHUR OXIDES AND NITROGEN OXIDES IN ALBERTA

VOLUME 2
DESIGN OF THE EMISSION INVENTORY

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EXECUTIVE SUMMARY

Air quality predictions play an important role in solving existing air pollution problems and in evaluating the potential impact of proposed emission sources. To predict air quality properly at a given location, it is necessary to identify all emission sources that will have significant impact at that location. Furthermore, the atmospheric pollutants that are emitted by these sources must be identified and quantitatively characterized. Once the air quality predictions have been made, it is desirable to have some historical air quality data for comparison. An efficient means of obtaining this information is through the use of detailed emission inventories and an inventory of air quality monitoring stations.

With specific regard to acid-forming emissions (i.e., sulphur dioxide and nitrogen oxides), it has been recognized that existing inventories for Alberta are either incomplete or do not provide sufficient detail to permit the investigation of specific regions within the province. Therefore, as part of the Alberta Government/Industry Acid Deposition Research Program (ADRP), three comprehensive inventories have been developed, namely:

- a sulphur dioxide (SO_2) emission inventory,
- a nitrogen oxides (NOx) emission inventory, and
- an inventory of air quality monitoring stations.

The basic objectives in developing these three inventories have been:

1. To identify all noteworthy anthropogenic sources of SO_2 and NOx emissions in Alberta. This includes all SO_2 and NOx emission sources that are licenced by the Alberta Government to operate under the Clean Air Act, sour oil batteries that emit more than 0.2 tonnes/day (t/d) of SO_2, and the following NOx emission sources:
   - industrial engines with a maximum rated power output of greater than 100 kW,
   - urban centres, and
   - the major portions of high traffic highways in the province (Highways 1, 2 and 16).

   Licenced industrial sources include natural gas processing facilities, oil refineries, oil sands and heavy oil recovery facilities, fertilizer and chemical plants, power generation plants, pulp and paper plants, and cement plants.

   Sources were identified on the basis of 1985-86 records available from government agencies and existing inventories. Emissions were estimated based on 1984 production data. Limited verification and updating of sources occurred in 1987.

2. To characterize each emission source, as appropriate, with respect to:
    - type of emission (i.e., NOx or SO_2),
    - geographic location (i.e., Legal Subdivision, Section, Township, and Range),
    - environmental setting (surrounding vegetation, ecoregion type),
    - physical characteristics (e.g., stack height and diameter),
    - maximum licenced emission rate (where applicable), and
    - emission characteristics (i.e., exit velocity, exit temperature, average emission rate, temporal variations and emission rate precision).

3. To conduct a limited NOx source sampling program in order to develop Alberta-specific NOx emission factors for natural gas fueled reciprocating and turbine engines, and to assess the importance of waste gas incinerator units as NOx emission sources.

4. To identify all air quality monitoring stations at which ambient levels of NOx and/or SO_2 are measured.

5. To computerize the inventories so that information may be easily retrieved and the inventories easily updated.

The three inventories are intended to serve as a source of information that will assist investigators in estimating the average rates of NOx and SO_2 emission in Alberta, and the distribution of these emissions by geographic area, industry type, and environmental setting (ecoregion). The inventories will also be useful in predicting changes in emission levels by the current emission sources due to future changes in production levels (i.e., forecasting future emissions). Administrative information, including operator name, approvals and regulatory information, is also provided for each industrial source to facilitate source-specific research.

To enable use of the emissions data base in emissions forecasting and to allow prediction of emission rates from sources for which actual emission data are unavailable, emission rates for each of the sources inventoried have been estimated based on the use of emission factors. Emission factors are average values that relate the emission of NOx or SO_2, as appropriate, to a suitable operating parameter of the sources (generally, process production data).

The estimated emission rates presented in the emissions data base are expressed as average daily values. As such, these emission rates have been averaged over the sum of both operating and non-operating periods (most emission sources experience some down time during the year, usually for maintenance purposes). Although estimates of typical emission rates during operating periods are not presented in the inventory, these values may be readily determined using available process production data and the presented emission factors.

The emissions data base comprises 565 sources of SO_2 emissions and 4025 sources of NOx emissions. In total, 1945.2 t/d of SO_2 and NOx emissions were inventoried, 1267.0 t/d of SO_2 and 678.2 t/d of NOx. The petroleum industry is by far the major source, accounting for approximately 38 percent of NOx emissions and 82 percent of SO_2 emissions. Other important sources are electric power plants (NOx and SO_2 emissions), highways (NOx emissions), and urban centres (NOx emissions).

Overall, it was determined that the majority of the SO_2 and NOx emissions (approximately 1398.0 t/d or 71.9 percent of the total) occur in the southern half of the province where industrial activity is greatest. Although numerous sources of these pollutants were identified, the total provincial emission of SO_2 and NOx is dominated by a few large sources rather than many smaller sources. The ten highest emitters of SO_2 account for 61.2 percent of the total SO_2 emissions, and the ten highest emitters of NOx account for 38.5 percent of the total NOx emissions.

The developed inventories have been computerized using a microcomputer-based data management system. The system chosen for this purpose was dBase III, a popular and powerful industry-standard database package that is designed for IBM and compatible computers. To assist users who may not be familiar with dBase III, a special application program named AAESI (an acronym for Alberta Atmospheric Emission Source Inventories) has been developed.

In addition to development of the three inventories that comprised this study, there are a number of other projects that are being conducted as part of the ADRP. One of these projects is a comprehensive air quality monitoring (AQM) program, involving three AQM stations. One AQM station is for the measurement of "background" air quality of air entering Alberta and is situated in the Fortress Mountain ski area of the Kananaskis Valley in the Rocky Mountains, 70 km west of Calgary, Alberta. The remaining two AQM stations are located 40 km north of Calgary on agricultural land near Crossfield, Alberta. One of the AQM stations is located west of Crossfield to assess air quality after the air has entered the Province of Alberta and been altered by regional scale emissions. The second AQM station is located southeast of Crossfield and is influenced by emissons from many sources such as Highway 2, City of Calgary, City of Airdrie, Town of Crossfield, two mushroom factories, and several sour gas (extraction) plants. A detailed survey of the incinerator stack from the sour gas plant closest to the second AQM station was included as part of the source sampling survey program conducted.

Documentation of the developed inventories is presented in four volumes. Volume 1, Overview of the Emission Data, comprises a brief summary describing development of the inventory, a summary of emissions data by emission type, geographic region, industrial category and ecoregion, a comparison with results of previous inventories, and a summary of the air quality monitoring station inventory. Conclusions and recommendations are also presented in this volume. Detailed summary tables describing emissions by major source category, petroleum industry facility type, and source type for each geographic emission region are appended to the volume.

Volume 2, Design of the Emission Inventory, presents detailed information on the classification systems, source characterization, emission calculations, and data fields employed for each emission type. Details describing the source sampling program conducted as part of the NOx inventory and the computerization of the inventories are also presented in this volume. Furthermore, a detailed discussion of some of the major air quality monitoring networks in Alberta is included.

Volume 3, Emission Data Base, is a complete printout of the three inventories.

Volume 4, Results of the Emission Source Surveys, presents detailed results of the surveys conducted as part of the emissions inventory.

This Executive Summary is common to all volumes.

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LIST OF SYMBOLS

Upper Case Letters	Definition
CF	annual per-capita natural gas consumption factor for urban centres in Alberta, TJ/person (10^{12} J/person)
DR	driver rate
E	electrical power generated, GW • h (10^6 kW • h)
EF	emission factor
ER	rate of emission of NOx or SO_2 in tonnes per day (t/d) or tonnes per day per kilometre (t/d/km)
GC	annual consumption of natural gas by an urban centre, TJ (10^{12} J)
L	length, km
LF	load factor
MP	maximum rated power output, kW
OT	operating-time factor
P	total population of an urban centre
TE	thermodynamic efficiency

Lower Case Letters

p	precision
s	standard deviation

Subscripts

B	indicates buses
COM	indicates the commercial sector
IND	indicates the industrial sector
PV	indicates passenger vehicles
RES	indicates the residential sector
RV	indicates recreation vehicles
SUT	indicates single unit trucks
TTU	indicates tractor-trailer combination units
VEH	indicates vehicular traffic
i	Alberta Transportation motor vehicle category (i.e., PV, RV, B, SUT or TTU); or COM, IND, RES or VEH
j	time period (i.e., first, second, third or fourth quarter of the year)

LIST OF ACRONYMS

Acronym	Definition
AAESI	Alberta Atmospheric Emission Source Inventory
ADRP	Acid Deposition Research Program
AQM	Air Quality Monitoring
CANSAP	Canadian Network for Sampling Precipitation
DMS	Data Management System
ERCB	Alberta Energy Resources Conservation Board
LSD	Legal Subdivision
RAM	Random Access Memory
SDF	System Data Format
SEC	Section
TWP	Township
RGE	Range
U.S. EPA	United States Environmental Protection Agency

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1. INTRODUCTION

This volume describes in detail the design of the SO_2 and NOx emission and air quality monitoring station inventories and the development of a computerized data base for these inventories. Sections 2 and 3 discuss the SO_2 and NOx emission inventories, respectively, describing classification systems, source classification, data sets, and emission rate calculations. A sample of each of the inventories is also presented. Section 3 also describes the source sampling program for NOx emissions.

Section 4 describes the inventory of air quality monitoring stations, discussing methodology and characterization of the stations. A sample of the inventory is presented, and additional information on climatological stations, air quality monitoring networks, and precipitation quality monitoring networks is also presented.

Section 5 describes the computerization of the inventories, discussing selection and implementation of a data management system and development of custom application programs. Quality assurance measures are also discussed and samples of report output formats presented.

2. SULPHUR DIOXIDE EMISSION INVENTORY

2.1 INTRODUCTION

The inventory of sulphur dioxide (SO_2) emissions in Alberta identifies all SO_2 emission sources licenced by Alberta Environment, and all sour oil batteries approved by Energy Resources Conservation Board (ERCB) that emit SO_2 at a rate of 0.2 tonnes per day (t/d) or more. The SO_2 values presented in the inventory are equivalent values and, as such, account for both SO_2 and SO_3 emissions.

Each SO_2 emission source that is identified in the inventory has been reduced to a stack or point source. Where more than one stack source occurs at a particular facility, an attempt has been made to define each of these sources on an individual basis. However, if there was insufficient information available to define the individual emission sources, these were lumped together and treated as a single point source.

To estimate the average emission rates for each source, emission factors have been employed. Where available, actual emission data have been used to determine these emission factors. Otherwise, emission factors were estimated based on values determined for similar sources.

Standards and Approvals Division, Alberta Environment, provided physical information (e.g., source location, stack height and diameter, and licenced emission rate) on all SO_2 emission sources that are a part of natural gas processing facilities. These constitute the majority of the licenced SO_2 emission sources, accounting for nearly half the SO_2 emissions in Alberta. Details of the licenced SO_2 emission sources associated with other types of facilities (i.e., refineries, power plants, oil sands plants, pulp and paper mills, fertilizer plants, heavy oil recovery plants and chemical plants) were obtained through contact with the operating companies and from the Alberta Environment SO_2 emissions inventory (Alberta Environment 1985).

Pollution Control Division, Alberta Environment provided actual emission data for many of the licenced sources of SO_2. These data were used to develop emission factors for the individual sources.

As previously indicated, information regarding sour oil batteries that emit 0.2 t/d of SO_2 or more were provided by ERCB.

2.2 CLASSIFICATION SYSTEM

In order to catalogue the identified SO_2 emissions in an organized manner for ease of computer data management, the individual emission sources have been classified according to the following criteria:

1. location, based on Alberta's legal land survey system (a map of Alberta is presented in Figure 1 and a description of Alberta's legal land survey system is presented in Figure 2),
2. type of source,
3. type of facility with which the source is associated, and
4. industry sector with which the facility is associated.

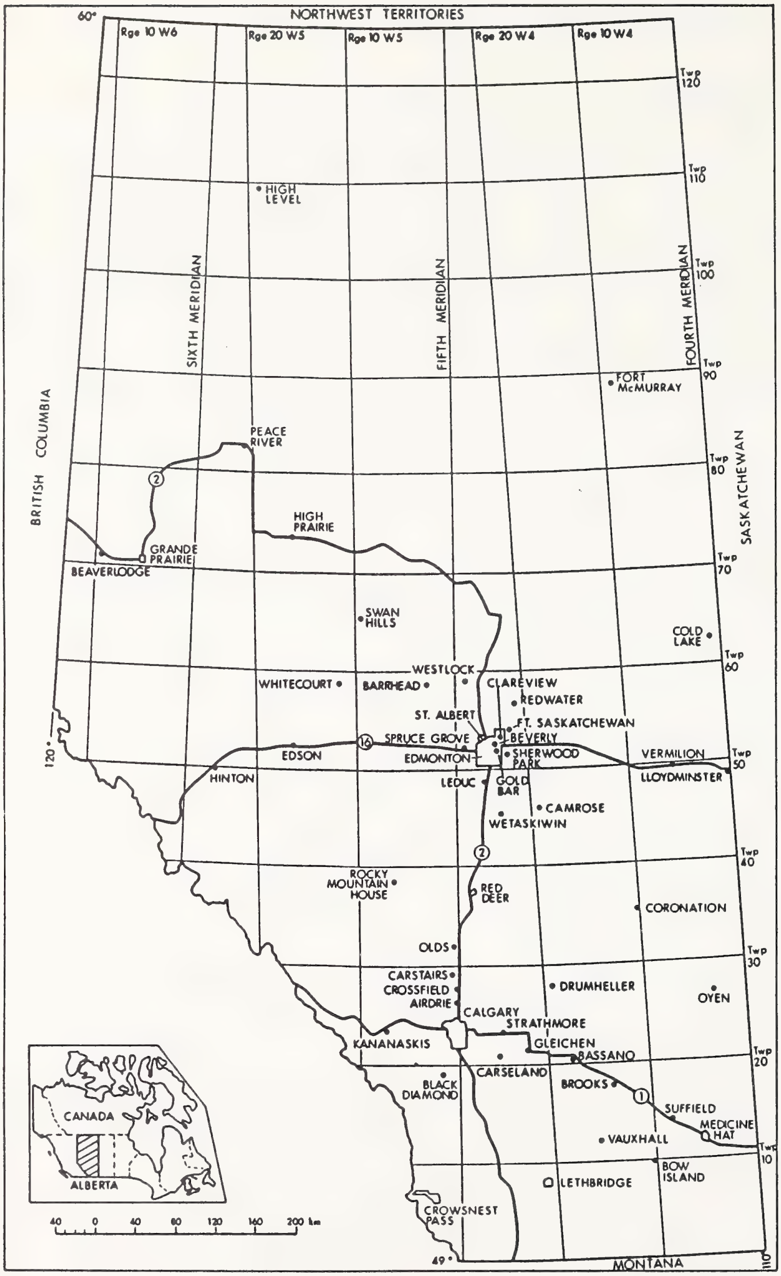
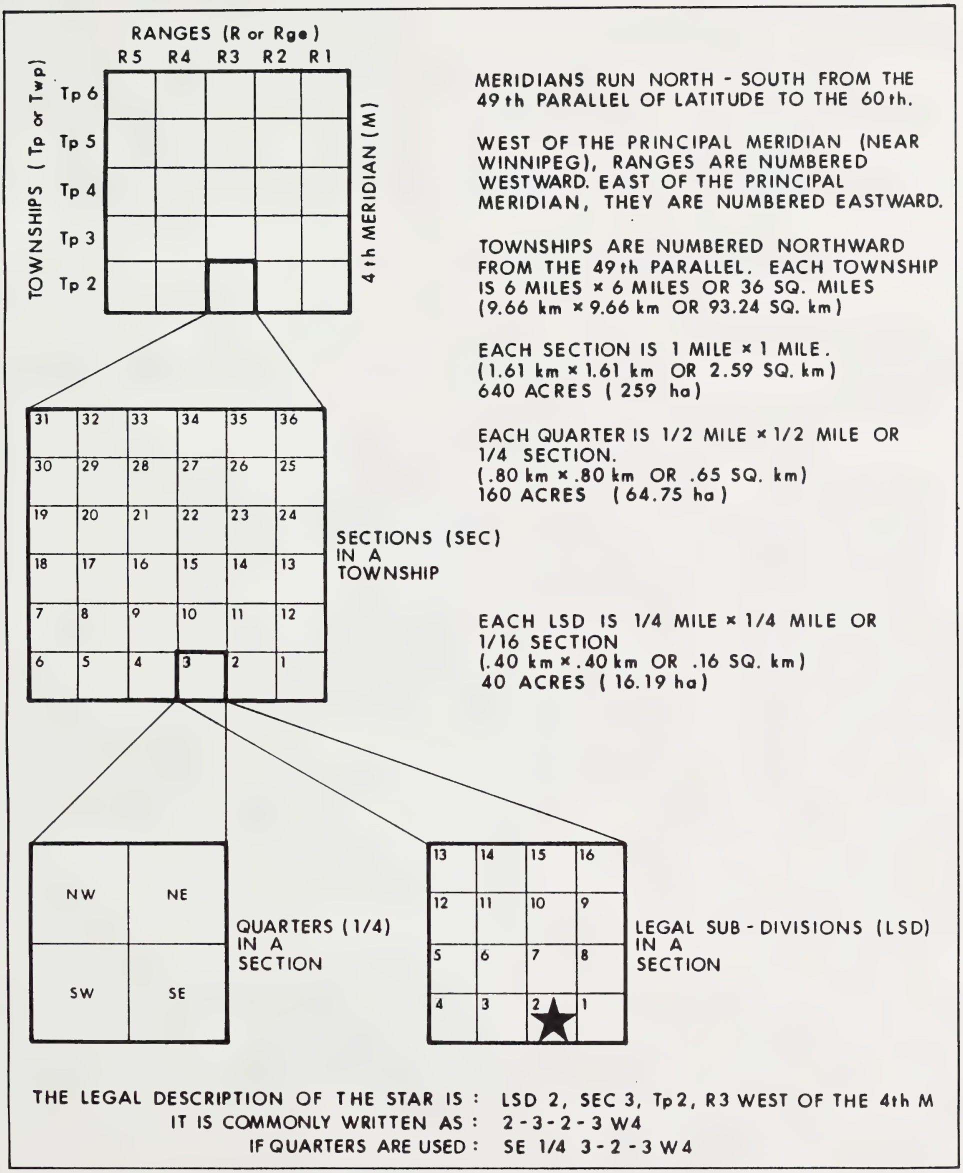


Figure 1. Map of Alberta showing Highways 1, 2 and 16, and selected urban centres.



MERIDIANS RUN NORTH - SOUTH FROM THE 49th PARALLEL OF LATITUDE TO THE 60th.

WEST OF THE PRINCIPAL MERIDIAN (NEAR WINNIPEG), RANGES ARE NUMBERED WESTWARD. EAST OF THE PRINCIPAL MERIDIAN, THEY ARE NUMBERED EASTWARD.

TOWNSHIPS ARE NUMBERED NORTHWARD FROM THE 49th PARALLEL. EACH TOWNSHIP IS 6 MILES × 6 MILES OR 36 SQ. MILES (9.66 km × 9.66 km OR 93.24 SQ. km)

EACH SECTION IS 1 MILE × 1 MILE.
(1.61 km × 1.61 km OR 2.59 SQ. km)
640 ACRES (259 ha)

EACH QUARTER IS 1/2 MILE × 1/2 MILE OR 1/4 SECTION.
(.80 km × .80 km OR .65 SQ. km)
160 ACRES (64.75 ha)

EACH LSD IS 1/4 MILE × 1/4 MILE OR 1/16 SECTION
(.40 km × .40 km OR .16 SQ. km)
40 ACRES (16.19 ha)

THE LEGAL DESCRIPTION OF THE STAR IS : LSD 2, SEC 3, Tp 2, R3 WEST OF THE 4th M
IT IS COMMONLY WRITTEN AS : 2-3-2-3 W4
IF QUARTERS ARE USED : SE 1/4 3-2-3 W4

Figure 2. Western Canada survey system.

A summary of the types of sources, facilities, and industries that have been used to classify the industrial sources of SO_2 is presented in Tables 1A to 1H. The terminology used in Table 1 is based upon that currently used by government and industry in Alberta.

In order to minimize computer memory requirements, the classification information for each emission source is presented in the inventory using short, readily identifiable letter codes. These letter codes are also shown in Tables 1A to 1H.

A brief discussion of the types of emission sources, facilities, and industries associated with the SO_2 emission inventory is presented in the following subsections.

2.2.1 Emission Source Types

In Alberta, there are essentially three different types of emission sources that emit 0.2 t/d or more of SO_2. These are sour gas flares and incinerators, and coal-fired boiler units. Sour gas flares and incinerators are typically used by the chemical, fertilizer, petroleum and pulp and paper industries, and coal-fired boiler units are normally associated with the electric utilities industry.

Flare stacks are a convenient and accepted means of disposing of small volumes of unwanted gases. They are often used for emergency situations and, in this service, operate on an intermittent basis only. However, flares are also used for continuous applications, namely, the disposal of toxic process waste (acid gas) streams from which the recovery of sulphur is uneconomical.

Although in this inventory it is assumed that all sulphur compounds which are disposed of through flare stacks are completely oxidized (i.e., converted to SO_2), flare stacks provide poor flame control and, therefore, may not be 100% effective in producing SO_2 (Colley et al. 1982; Leahey et al. 1985). A more effective, more costly means of doing this is to use incinerators.

Incinerators are better able to achieve complete oxidation through the use of controlled combustion chambers. However, because of their higher cost, they normally are used only when low energy and/or large volumes of waste materials are to be destroyed or "combusted". In Alberta, the most common occurrence of incinerators is in the petroleum industry where they are used to oxidize waste gas from sulphur recovery units.

In addition to having large quantities of oil and gas, Alberta also has vast coal reserves. As a result, there are several coal-fired power plants in the province. Although Alberta coal is relatively low in sulphur, typically 0.6% (or less) sulphur compared with levels as high as 6.0% in some coals used in the United States (Dibbs and Marier 1973), sufficient volumes are consumed by these plants to result in significant SO_2 emissions. Approximately one-sixth of the total industrial SO_2 emissions in Alberta may be attributed to coal-fired power plants.

2.2.2 Facility and Industry Types

In Alberta there are five industry sectors to which SO_2 emissions may be attributed. These industries, and the types of facilities they operate, are listed in Tables 1A and 1B. The letter codes used in the inventory to denote these are also presented in these tables.

Table 1A. SO_2 inventory: types of industry sectors and facilities, and their respective codes.

Industry	Industry Code	Facility	Facility Code
1. Chemical	CHE	Chemical Plant	CHP
2. Electric Utilities	ELE	Power Generation Plant	PGP
3. Fertilizer	FER	Fertilizer Plant	FP
4. Petroleum	PET	Sour Gas (Extraction) Plant	EGP
		Sour Gas (Flaring) Plant	FGP
		Oil Battery	OB
		Oil Sands Plant	OSP
		Heavy Oil Recovery Plant	HOP
		Refinery	R
5. Pulp and Paper	PUL	Pulp and Paper Mill	PPM

Table 1B. SO_2 inventory: types of emission sources and their respective codes.

Source Type	Code
Coal-fired boiler unit	BOILER
Flare	FLARE
Incinerator unit	INCIN

Table 1C. SO_2 inventory: qualifier code.

Description	Code
Sulphur Recovery Unit	SRU
Dehydration Unit	DHY
Power Generation Unit	GEN

Table 1D. SO_2 inventory: types of emission source operating modes and their respective codes.

Operating Mode	Code
Continuous	CON
Emergency	EMR
Not Currently Operating	NCO
Standby	STB
Suspended	SUS
To-be-Constructed	TBC

Table 1E. SO_2 inventory: types of emission drivers and their respective codes.

Driver Type	Units	Code
Coal consumed.	Tonnes consumed per day (t/d).	C
Electrical power generated.	Millions of kilowatt-hours generated per day (GW•h/d).	E
SO_2 emissions appeared to be independent parameters; therefore no driver was used	Dimensionless.	N
Sulphur extracted.	Tonnes extracted per day (t/d).	S
Total gas receipts.	Thousands of cubic metres received per day ($10^3 m^3/d$ referenced at 15°C and 101.325 kPa).	G

Table 1F. SO_2 inventory: methods used to evaluate the emission factors.

Method of Evaluation	Code
Evaluated based on available emission data.	EVA
Estimated by taking the average of emission factors available for similar sources.	EST

Table 1G. SO_2 inventory: environmental-setting codes.

Environmental Setting	Code
Agriculture	AGR
Forest	FOR
Grass	GRA
Muskeg	MUS
Shrubs	SHR

Table 1H. Ecoregions in Alberta[1].

Ecoregion	Description
1	Short Grass
2	Mixed Grass
3	Fescue Grass
4	Aspen Parkland
5	Montane
6	Subalpine
7	Alpine
8	Boreal Mixedwood
9	Boreal Foothills
10	Boreal Uplands
11	Boreal Northlands
12	Boreal Subarctic

[1] An ecoregion is defined as "an area characterized by a destinctive regional climate as expressed by vegetation" (Subcommittee on Biophysical Land Classification 1969).

Source: Strong and Leggat (1981)

2.3 SOURCE CHARACTERIZATION

2.3.1 Data Set

The basic data set that has been used to characterize each source of SO_2 emissions is as follows:

1. Location - The location of each source based on Alberta's legal land system (see Figures 1 and 2).
2. Industry Sector - The industry sector responsible for the emission source (see Table 1A).
3. Facility Type - The type of facility responsible for the emission source (see Table 1A).
4. Facility Name - The designated name of the facility.
5. Operator - The name of the company that operates the facility.
6. ERCB Approval Number - Where initial construction and operation of a facility has been approved by the ERCB, the reference approval number issued for this purpose.
7. Clean Air Act Licence Number - Where the emission of SO_2 from a given facility has been licenced under the Clean Air Act, the reference licence number issued by Alberta Environment.
8. Source Type - The type of emission source (see Table 1B).
9. Qualifier - A general term or phrase that may be used to:
    - indicate the overall piece of equipment, or unit, with which the emission source is associated (e.g., an incinerator might be noted as being part of a sulphur recovery unit);
    - indicate the primary function of the emission source (e.g., a flare might be noted as being high pressure, low pressure, or acid gas flare); or
    - distinguish between two or more emission sources of the same type which are located at the same facility (e.g., if two incinerators are located at the same facility these might be distinguished using the equipment codes employed by the operator or the terms new and old).

   The different codes that have been used as qualifiers are defined in Table 1C.
10. Operating Mode - Each emission source has been identified as operating on either a continuous (CON), standby (STB) or emergency (EMR) basis. Units to-be-constructed (TBC), suspended (SUS), or which are not currently operating (NCO) were also identified (see Table 1D).
11. Emission Driver - The operating parameter to which emissions from a particular source have been related (see Table 1E).
12. Emission Driver Value - The average value of the emission driver under normal operating conditions, expressed as an effective daily rate. Where sufficient information was available, average values have been determined for each quarter of the year. Otherwise, a single representative value has been determined. The data used to evaluate the driving parameter values were obtained from the annual ERCB statistical reports (ERCB 1985 a-d).

13. Precision of the Driving Parameter - An estimate of the degree to which actual values of the driving parameters will normally vary from the values listed in the inventory. Values of driving parameter precision were evaluated based on data available in the annual ERCB statistical reports (ERCB 1985 a-d).
14. Emission Factor - The factor by which the driving parameter has been multiplied in order to evaluate emission rates.
15. Source of Emission Factor - The method by which values of the emission factor were obtained (see Table 1F).
16. Emission Factor Precision - An estimate of the degree to which the true value of the emission factor will normally vary from the values listed in the inventory.
17. Emission Rate - The calculated rate, in tonnes per day (t/d), at which SO_2 is emitted.
18. Emission Rate Precision - The degree to which the actual emission rates will normally fluctuate from the values calculated in the inventory.
19. Operating Time - The amount of time during which the emission source is expected to be operating (a value of 1.0 indicates continuous operation).
20. Licenced Emission Rate - Where appropriate, the maximum SO_2 emission rate (t/d) specified in a facility's Clean Air Act Licence.
21. Source Characteristics - This includes:
    - stack height (m),
    - inside diameter at the stack outlet (m),
    - base elevation (m),
    - stack exit temperature (°C), and
    - exit gas velocity (m/s).
22. Site Characteristics - This includes the surrounding environmental setting (see Table 1G) and the ecoregion (see Table 1H).

2.3.2 Emission Rate Calculation and Analysis

To characterize the rate at which SO_2 or NOx is emitted from a given source, emission data and relevant operating data should, ideally, be readily available for that individual source. In this way, investigators could develop correlations and observe temporal variations at a resolution appropriate to their specific needs. However, such data are normally difficult to obtain or are unavailable. As a result, certain simplifying assumptions must be made.

As a first approximation, it could be assumed that actual emissions are, on average, equal to the maximum design or licenced values. However, it has been observed during the development of this inventory that actual SO_2 emissions are, in general, significantly lower than the licenced values (typically oneto two-thirds of the licenced values).

The common approach, and that which has been used in this study, is to estimate emission rates using an expression of the form:

$$ER = EF \cdot DR \qquad [1]$$

where,

ER = estimated rate of emission in tonnes per day (t/d)
EF = emission factor
DR = driver rate

The driver rate is equal to the value of the emission-source operating parameter to which the emission rate has been related. Different operating parameters were used for different types of emission sources. A list of those used in the SO_2 inventory is presented in Table 1E.

The DR values were determined for each quarter of the emission year being considered (i.e., 1985 for the present inventories) using data obtained from the statistics reports published by Energy Resources Conservation Board (ERCB 1985 a-d). The DR value presented for each quarter is an average of the data available for that quarter.

If, for a particular emission source, actual rates of emission appeared to be independent of any operating parameter then no (N) driver was used. In such cases, the value of DR was set to unity, and the value of EF presented in the inventory was set equal to the average value of the available emission rate data.

The emission factors presented in the SO_2 inventory have been determined in one of the following two ways:

1. Evaluated (EVA) - If emission data were available for a given source, emission factors were evaluated from the data, with the mean value being used in the inventory.
2. Estimated (EST) - If emission data were unavailable for a given source, the emission factor was taken to be the average of emission factors evaluated for other emission sources of the same type.

For the cases in which EF values were evaluated using available data, there were no apparent seasonal dependencies.

To indicate the quality of the emission factors that had been evaluated or estimated, the precision of each was determined. The method to determine the precision values is basically that employed previously by PEDCO-Environmental Specialists, Incorporated (1974).

Precision was defined as a measure of the variability due to unknown factors that affects a measurement made on similar elements from a population. Based on the assumption of random variability, the precision of each average EF value was calculated using the equation:

$$p(EF) = s/EF \qquad [2]$$

where,

$p(EF)$ = precision of EF,
s = standard deviation of the sample set.

To determine the precision of an EF value that had been evaluated, the sample set was taken to be the set of emission factors determined from the available emission data. For estimated EF values, the sample set was taken to be the set of emission factors from similar sources that had been used.

In addition to determining the precision of each EF value, the precision was also determined for each DR and ER value. The driver rate precision values were determined using the same methodology as was applied to emission factors; i.e., the following equation was employed:

$$p(DR) = s/DR \qquad [3]$$

where,

p(DR) = precision of DR.

Finally, to determine the precision of each ER value, the following equation was used:

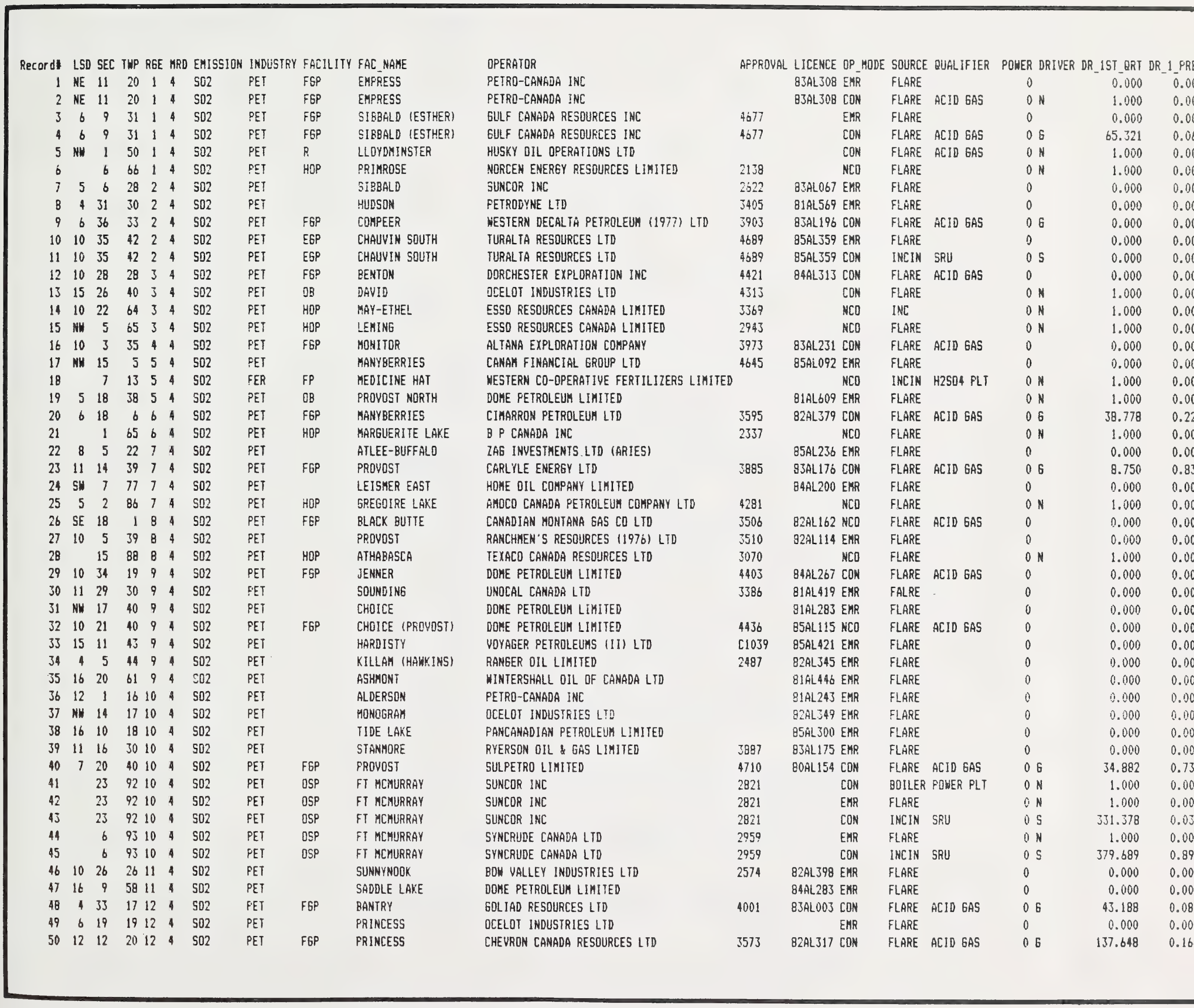
$$p(ER) = [p(EF)^2 + p(DR)^2]^{1/2} \qquad [4]$$

where,

p(ER) = precision of ER.

2.4 SAMPLE OF THE INVENTORY

A sample of the developed inventory of SO_2 emission sources is presented in Figure 3. The field headings that appear in Figure 3 are defined in Table 2. All letter codes and abbreviations which are used in the inventory are defined in Tables 1A to 1G.



Record#	LSD	SEC	TWP	RGE	MRD	EMISSION	INDUSTRY	FACILITY	FAC_NAME	OPERATOR	APPROVAL	LICENCE	OP_MODE	SOURCE	QUALIFIER	POWER	DRIVER	DR_1ST_QRT	DR_1_PR
1	NE	11	20	1	4	S02	PET	FGP	EMPRESS	PETRO-CANADA INC		83AL308	EMR	FLARE		0		0.000	0.0
2	NE	11	20	1	4	S02	PET	FGP	EMPRESS	PETRO-CANADA INC		83AL308	CON	FLARE	ACID GAS	0	N	1.000	0.0
3	6	9	31	1	4	S02	PET	FGP	SIBBALD (ESTHER)	GULF CANADA RESOURCES INC	4677		EMR	FLARE		0		0.000	0.0
4	6	9	31	1	4	S02	PET	FGP	SIBBALD (ESTHER)	GULF CANADA RESOURCES INC	4677		CON	FLARE	ACID GAS	0	G	65.321	0.0
5	NW	1	50	1	4	S02	PET	R	LLOYDMINSTER	HUSKY OIL OPERATIONS LTD			CON	FLARE	ACID GAS	0	N	1.000	0.00
6		6	66	1	4	S02	PET	HOP	PRIMROSE	NORCEN ENERGY RESOURCES LIMITED	2138		NCO	FLARE		0	N	1.000	0.00
7	5	6	28	2	4	S02	PET		SIBBALD	SUNCOR INC	2622	83AL067	EMR	FLARE		0		0.000	0.00
8	4	31	30	2	4	S02	PET		HUDSON	PETRODYNE LTD	3405	81AL569	EMR	FLARE		0		0.000	0.00
9	6	36	33	2	4	S02	PET	FGP	COMPEER	WESTERN DECALTA PETROLEUM (1977) LTD	3903	83AL196	CON	FLARE	ACID GAS	0	G	0.000	0.00
10	10	35	42	2	4	S02	PET	EGP	CHAUVIN SOUTH	TURALTA RESOURCES LTD	4689	85AL359	EMR	FLARE		0		0.000	0.00
11	10	35	42	2	4	S02	PET	EGP	CHAUVIN SOUTH	TURALTA RESOURCES LTD	4689	85AL359	CON	INCIN	SRU	0	S	0.000	0.00
12	10	28	28	3	4	S02	PET	FGP	BENTON	DORCHESTER EXPLORATION INC	4421	84AL313	CON	FLARE	ACID GAS	0		0.000	0.00
13	15	26	40	3	4	S02	PET	OB	DAVID	OCELOT INDUSTRIES LTD	4313		CON	FLARE		0	N	1.000	0.00
14	10	22	64	3	4	S02	PET	HOP	MAY-ETHEL	ESSO RESOURCES CANADA LIMITED	3369		NCO	INC		0	N	1.000	0.00
15	NW	5	65	3	4	S02	PET	HOP	LEMING	ESSO RESOURCES CANADA LIMITED	2943		NCO	FLARE		0	N	1.000	0.00
16	10	3	35	4	4	S02	PET	FGP	MONITOR	ALTANA EXPLORATION COMPANY	3973	83AL231	CON	FLARE	ACID GAS	0		0.000	0.00
17	NW	15	5	5	4	S02	PET		MANYBERRIES	CANAM FINANCIAL GROUP LTD	4645	85AL092	EMR	FLARE		0		0.000	0.00
18		7	13	5	4	S02	FER	FP	MEDICINE HAT	WESTERN CO-OPERATIVE FERTILIZERS LIMITED			NCO	INCIN	H2SO4 PLT	0	N	1.000	0.00
19	5	18	38	5	4	S02	PET	OB	PROVOST NORTH	DOME PETROLEUM LIMITED		81AL609	EMR	FLARE		0	N	1.000	0.00
20	6	18	6	6	4	S02	PET	FGP	MANYBERRIES	CIMARRON PETROLEUM LTD	3595	82AL379	CON	FLARE	ACID GAS	0	G	38.778	0.22
21		1	65	6	4	S02	PET	HOP	MARGUERITE LAKE	B P CANADA INC	2337		NCO	FLARE		0	N	1.000	0.00
22	8	5	22	7	4	S02	PET		ATLEE-BUFFALO	ZAG INVESTMENTS LTD (ARIES)		85AL236	EMR	FLARE		0		0.000	0.00
23	11	14	39	7	4	S02	PET	FGP	PROVOST	CARLYLE ENERGY LTD	3885	83AL176	CON	FLARE	ACID GAS	0	G	8.750	0.83
24	SW	7	77	7	4	S02	PET		LEISMER EAST	HOME OIL COMPANY LIMITED		84AL200	EMR	FLARE		0		0.000	0.00
25	5	2	86	7	4	S02	PET	HOP	GREGOIRE LAKE	AMOCO CANADA PETROLEUM COMPANY LTD	4281		NCO	FLARE		0	N	1.000	0.00
26	SE	18	1	8	4	S02	PET	FGP	BLACK BUTTE	CANADIAN MONTANA GAS CO LTD	3506	82AL162	NCO	FLARE	ACID GAS	0		0.000	0.00
27	10	5	39	8	4	S02	PET		PROVOST	RANCHMEN'S RESOURCES (1976) LTD	3510	82AL114	EMR	FLARE		0		0.000	0.00
28		15	88	8	4	S02	PET	HOP	ATHABASCA	TEXACO CANADA RESOURCES LTD	3070		NCO	FLARE		0	N	1.000	0.00
29	10	34	19	9	4	S02	PET	FGP	JENNER	DOME PETROLEUM LIMITED	4403	84AL267	CON	FLARE	ACID GAS	0		0.000	0.00
30	11	29	30	9	4	S02	PET		SOUNDING	UNOCAL CANADA LTD	3386	81AL419	EMR	FALRE		0		0.000	0.00
31	NW	17	40	9	4	S02	PET		CHOICE	DOME PETROLEUM LIMITED		81AL283	EMR	FLARE		0		0.000	0.00
32	10	21	40	9	4	S02	PET	FGP	CHOICE (PROVOST)	DOME PETROLEUM LIMITED	4436	85AL115	NCO	FLARE	ACID GAS	0		0.000	0.00
33	15	11	43	9	4	S02	PET		HARDISTY	VOYAGER PETROLEUMS (II) LTD	C1039	85AL421	EMR	FLARE		0		0.000	0.00
34	4	5	44	9	4	S02	PET		KILLAM (HAWKINS)	RANGER OIL LIMITED	2487	82AL345	EMR	FLARE		0		0.000	0.00
35	16	20	61	9	4	S02	PET		ASHMONT	WINTERSHALL OIL OF CANADA LTD		81AL446	EMR	FLARE		0		0.000	0.00
36	12	1	16	10	4	S02	PET		ALDERSON	PETRO-CANADA INC		81AL243	EMR	FLARE		0		0.000	0.00
37	NW	14	17	10	4	S02	PET		MONOGRAM	OCELOT INDUSTRIES LTD		82AL349	EMR	FLARE		0		0.000	0.00
38	16	10	18	10	4	S02	PET		TIDE LAKE	PANCANADIAN PETROLEUM LIMITED		85AL300	EMR	FLARE		0		0.000	0.00
39	11	16	30	10	4	S02	PET		STANMORE	RYERSON OIL & GAS LIMITED	3887	83AL175	EMR	FLARE		0		0.000	0.00
40	7	20	40	10	4	S02	PET	FGP	PROVOST	SULPETRO LIMITED	4710	80AL154	CON	FLARE	ACID GAS	0	G	34.882	0.73
41		23	92	10	4	S02	PET	OSP	FT MCMURRAY	SUNCOR INC	2821		CON	BOILER	POWER PLT	0	N	1.000	0.00
42		23	92	10	4	S02	PET	OSP	FT MCMURRAY	SUNCOR INC	2821		EMR	FLARE		0	N	1.000	0.00
43		23	92	10	4	S02	PET	OSP	FT MCMURRAY	SUNCOR INC	2821		CON	INCIN	SRU	0	S	331.378	0.03
44		6	93	10	4	S02	PET	OSP	FT MCMURRAY	SYNCRUDE CANADA LTD	2959		EMR	FLARE		0	N	1.000	0.00
45		6	93	10	4	S02	PET	OSP	FT MCMURRAY	SYNCRUDE CANADA LTD	2959		CON	INCIN	SRU	0	S	379.689	0.89
46	10	26	26	11	4	S02	PET		SUNNYNOOK	BOW VALLEY INDUSTRIES LTD	2574	82AL398	EMR	FLARE		0		0.000	0.00
47	16	9	58	11	4	S02	PET		SADDLE LAKE	DOME PETROLEUM LIMITED		84AL283	EMR	FLARE		0		0.000	0.00
48	4	33	17	12	4	S02	PET	FGP	BANTRY	GOLIAD RESOURCES LTD	4001	83AL003	CON	FLARE	ACID GAS	0	G	43.188	0.08
49	6	19	19	12	4	S02	PET		PRINCESS	OCELOT INDUSTRIES LTD			EMR	FLARE		0		0.000	0.00
50	12	12	20	12	4	S02	PET	FGP	PRINCESS	CHEVRON CANADA RESOURCES LTD	3573	82AL317	CON	FLARE	ACID GAS	0	G	137.648	0.16

Figure 3. A sample of the SO_2 inventory.

ER	DR_1ST_QRT	DR_1_PREC	DR_2ND_QRT	DR_2_PREC	DR_3RD_QRT	DR_3_PREC	DR_4TH_QRT	DR_4_PREC	DR_YEAR	EF	EF_PREC	EF_YEAR	EF_SOURCE	ER_1ST_QRT	ER_1_PREC	ER_2ND_QRT	ER
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000		0.15700	0.452	1983	EVA	0.157	0.452	0.157	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	65.321	0.067	21.366	1.277	15.086	1.732	55.670	0.053		0.00000	0.000			0.000	0.067	0.000	
	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000		0.00000	0.000		EST	0.000	0.000	0.000	
	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	0.000	0.000	61.069	0.331	62.701	0.503	43.125	0.867		0.00000	0.000			0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000		0.79100	0.440	1983	EVA	0.791	0.440	0.791	
	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000		0.00000	0.000		EST	0.000	0.000	0.000	
	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000		0.00000	0.000		EST	0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	38.778	0.223	25.102	0.341	5.741	0.895	0.000	0.000		0.00000	0.000			0.000	0.223	0.000	
	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000		0.00000	0.000		EST	0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	8.750	0.837	0.262	0.877	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.837	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000		0.00000	0.000		EST	0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000		0.00000	0.000		EST	0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	34.882	0.731	0.000	0.000	9.899	1.732	34.468	0.140		0.00000	0.000			0.000	0.731	0.000	
	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000		135.40000	0.000	1983	EST	135.400	0.000	135.400	
	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000		31.60000	0.000	1983	EST	31.600	0.000	31.600	
	331.378	0.034	265.508	0.296	299.040	0.099	286.127	0.104	1984	0.09198	0.125	1983	EVA	30.480	0.130	24.421	
	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000		32.40000	0.000	1983	EST	32.400	0.000	32.400	
	379.689	0.894	838.449	0.021	474.136	0.823	478.299	0.155	1984	0.23813	0.176	1983	EVA	90.415	0.911	199.660	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	43.188	0.086	51.151	0.066	47.114	0.055	57.995	0.021	1984	0.01165	0.177	1983	EVA	0.503	0.197	0.596	
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000	
	137.648	0.166	64.477	0.898	57.339	1.732	152.723	0.172	1984	0.00172	0.026	1983	EVA	0.237	0.168	0.111	

Table 2. SO_2 emission inventory: definition of the field headings.

Field Heading	Definition
LSD	Legal subdivision in which the emission source is located.
SEC	Section in which the emission source is located.
TWP	Township in which the emission source is located.
RGE	Range in which the emission source is located.
MRD	Closest meridian located east of the emission source.
EMISSION	Type of emission (i.e., NOx or SO_2).
INDUSTRY	Industry sector with which the facility is associated (see Table 1A).
FACILITY	Type of facility of which the emission source is a part (see Table 1A).
FAC-NAME	Name of the facility.
OPERATOR	Name of the company which operates the facility.
APPROVAL	Approval number of facilities which have been approved by ERCB.
LICENCE	Licence number of facilities which have been licenced to operate under the Clean Air Act.
OP-MODE	Operating mode of the emission source (see Table 1D).
SOURCE	Type of emission source (see Table 1B).

Continued...

Table 2 (continued).

Field Heading	Definition
QUALIFIER	A statement which serves to uniquely identify an emission source when more than one of the same type occur at the same facility.
POWER	Rated power output of the emission source, kW.
DRIVER	Type of emission driver (see Table 1E).
DR-1ST-QRT	Average daily value of the emission driver during the first quarter.
DR-1-PREC	Precision of the first-quarter driver rate.
DR-2ND-QRT	Average daily value of the emission driver during the second quarter.
DR-2-PREC	Precision of the second-quarter driver rate.
DR-3RD-QRT	Average daily value of the emission driver during the third quarter.
DR-3-PREC	Precision of the third-quarter driver rate.
DR-4TH-QRT	Average daily value of the emission driver during the fourth quarter.
DR-4-PREC	Precision of the fourth-quarter driver rate.
DR-YEAR	Year for which the driver rate values are presented.
EF	Emission factor.
EF-PREC	Precision of the emission factor.

Continued...

Table 2 (continued).

Field Heading	Definition
EF-YEAR	Year in which the emission factor was determined.
EF-SOURCE	Method by which the emission factor was determined (see Table 1F).
ER-1ST-QRT	Average daily rate of SO_2 emission during the first quarter, t/d.
ER-1-PREC	Precision of the first-quarter emission rate.
ER-2ND-QRT	Average daily rate of SO_2 emission during the second quarter, t/d.
ER-2-PREC	Precision of the second-quarter emission rate.
ER-3RD-QRT	Average daily rate of SO_2 emission during the third quarter, t/d.
ER-3-PREC	Precision of the third-quarter emission rate.
ER-4TH-QRT	Average daily rate of SO_2 emission during the fourth quarter, t/d.
ER-4-PREC	Precision of the fourth-quarter emission rate.
ER-AVERAGE	Average annual daily rate of SO_2 emission, t/d.
LIC-ER	Where applicable, the maximum licenced rate of emission, t/d.
OPR-TIME	The fraction of the time during which the emission source is operating (1.0 indicates continuous usage).
STACK-HT	Stack height, m.

Continued...

Table 2 (concluded).

Field Heading	Definition
STACK-DIA	Inside diameter at the stack outlet, m.
SITE-ELEV	Elevation of the site above sea level, m.
EXIT-VEL	Exit velocity of the stack effluent, m/s.
EXIT-TEMP	Exit temperature of the stack effluent, °C.
ECOREGION	Ecoregion (see Table 1H), in which the facility is located.
ENV-SETTING	Environmental setting (see Table 1G).

3. NITROGEN OXIDES EMISSION INVENTORY

3.1 INTRODUCTION

The inventory of NOx emissions has been divided into three separate sections according to the type of source. These sections are:

- industrial sources,
- urban centre sources, and
- highway sources.

Since the characteristics of each of the three NOx emission-source categories are quite different, three different inventory formats have been used. Delineation of these is provided in the following subsections.

All NOx emissions have been quantitatively expressed in terms of equivalent amounts of NO_2.

3.1.1 Industrial Sources

The inventory of industrial NOx emission sources includes,

- all NOx emission sources currently licenced to operate under the Clean Air Act, and
- all NOx emission sources approved by ERCB that have a maximum rated power output of 100 kW or more.

The majority of the licenced sources emit NOx as a product of combustion. There are, however, three fertilizer plants in the province that also emit NOx as a by-product of a chemical manufacturing process, namely, the production of nitric acid by the catalytic oxidation of ammonia. These three plants are:

- C-I-L Inc., Carseland;
- Esso Chemical Alberta Limited, Redwater; and
- Western Co-operative Fertilizers Limited, Calgary.

NOx emissions from the unlicenced sources are a result of fuel combustion only.

The types of industrial sources, licenced and unlicenced, that emit NOx as a product of fuel combustion include:

- natural gas fueled reciprocating engines,
- natural gas fueled turbine engines, and
- boiler, heater, or kiln units.

The basic approach that has been taken in developing the NOx emission inventory for industrial sources is the same as that used for the SO_2 emission inventory. Each industrial NOx source has been reduced to a stack or point source. Where more than one stack occurs at a given facility, an attempt has been made to define each of these sources on an individual basis. If there was insufficient information available to allow proper characterization of the individual emission sources, these were lumped together and treated as a single point source.

Where necessary, NOx emission rates have been estimated using emission factors, and some use has been made of emission factors published by the U.S. Environmental Protection Agency (U.S. EPA, 1985). The U.S. EPA values have been used in cases where insufficient data were available to enable emission factors to be determined or estimated based on information available through tests or studies in Alberta.

Except for certain of the larger sources (i.e., coal-fired boiler units and nitric acid plants), NOx emission monitoring is generally not conducted in Alberta. As a result, only limited data were available for use in developing NOx emission factors. In order to minimize reliance on U.S. EPA emission factors, and to address concerns that use of these might not properly reflect typical operating and environmental conditions in Alberta, a limited NOx source sampling program was conducted.

The source sampling program focussed primarily on natural gas fueled reciprocating and turbine engines since these are the major industrial sources of NOx emissions in Alberta, accounting for approximately 75% of the total NOx emissions by industrial sources. However, several waste gas incinerator units were also included in the program as there was some question regarding the significance of NOx emissions from these.

A total of 22 NOx emission sources were surveyed as part of the sampling program. These included 12 reciprocating engines, six turbine engines and four waste gas incinerator units. The overall results of the program are summarized in Section 3.2.3. Detailed results for each of the surveyed emission sources are presented in Volume 4, Section 2.

In developing the inventory for industrial NOx emission sources, Alberta Environment and the Energy Resources Conservation Board (ERCB) served as the primary sources of information. The Standards and Approvals Division of Alberta Environment provided a listing of all licenced NOx emission sources associated with the production and processing of natural gas. Using information contained in the licence applications, Standards and Approvals Division was also able to provide most of the physical information used to characterize the individual sources. The majority of the stack sources of NOx that were identified through Alberta Environment were internal combustion engines (i.e., turbine engines and reciprocating engines). The vast majority of these are used to drive large natural gas compressor units, oil pumping units, and water injection units. Only compression and pumping facilities having a total on-site internal combustion driver capacity of at least 746 kW are of concern to Alberta Environment. To consider facilities with less than 746 kW driver capacity, ERCB was used as an additional source of information. Through the ERCB, all engines having a maximum rated power output greater than 100 kW were identified.

Through the Pipeline Department of ERCB, a listing of all compressor stations involved in gas transmission was obtained. In addition, this department provided access to all gathering system files. These were reviewed for compression and pumping facilities of less than 746 kW.

Through the Development Department of ERCB, access was obtained to all files on oil batteries. These were also reviewed for compression and pumping facilities of less than 746 kW.

Electric drivers are not a source of atmospheric emissions; however, for completeness they have been identified in the inventory.

The inventory of Legge and Baker (1987) also served as a means of checking some data obtained from Alberta Environment and the ERCB. An additional means of checking the collected data was through comparison with data listed in Oilweek Magazine.

Other sources of information were the operating companies, themselves, and the NOx emissions inventory by Alberta Environment (1984).

3.1.2 Urban Centre Sources

All villages, towns, and cities in the province, as defined by Alberta Municipal Affairs (1985), have been treated as area, or distributed sources, of NOx emissions. In doing so, NOx emissions have been attributed to vehicular traffic and to the residential, commercial and industrial consumption of natural gas.

A listing of all urban centres in the province and their respective size (i.e., land area) and population was obtained from Alberta Municipal Affairs (1985). Data provided by Canadian Western Natural Gas Company Limited and Northwestern Utilities Limited were then used to establish per capita use patterns in residential, commercial, and industrial gas consumption. From these patterns, typical natural gas consumption figures were developed for each urban centre. Using published emission factors (U.S. EPA, 1985), it was then possible to calculate probable rates of NOx emission due to natural gas consumption.

Based on previous work by Western Research (1976 a,b), the ratio of annual NOx emissions resulting from space heating (i.e., non-industrial consumption of natural gas) to those from vehicular traffic is equal to approximately 0.3 for the cities of Calgary and Edmonton. Data were insufficient to determine such information for each urban centre; therefore, it was assumed that a similar relationship between NOx emissions due to vehicular traffic and those due to space heating would currently apply to all urban centres. The NOx emissions due to vehicular traffic and natural gas consumption were then calculated for each urban centre.

3.1.3 Highway Sources

The three main sections of highway in the province have been divided into a number of short segments and treated as line sources of NOx emissions. These sections consist of all of Highways 1 and 16, and Highway 2 from Westlock, located approximately 70 km north of Edmonton, south to the U.S. border. All other roadways were considered to be insignificant sources of NOx.

For each highway segment, average daily vehicle volumes and type distribution data have been used along with NOx emission factors and average travelling speeds to calculate probable NOx emission rates. The vehicle data were obtained through the Transportation Safety Branch of Alberta Transportation (1985), and appropriate emission factors were provided by the Industrial Program Branch of the Environmental Protection Service of Environment Canada (Environment Canada, Environmental Protection Service, letter 1985).

3.2 INDUSTRIAL SOURCES

3.2.1 Classification System

The basic classification system used to catalogue the individual industrial sources of NOx is the same as that described in Section 2.2 for SO_2 emission sources. A summary of the different industry sectors, facilities, NOx emission sources, emission source qualifiers, emission source operating codes, NOx emission drivers, and methods used to evaluate the NOx emission factors in the NOx inventory is presented in Tables 3A to 3F. The environmental settings and ecoregions are as defined previously in Tables 1G and 1H.

There are basically four types of industrial sources of NOx emissions. These are:

- nitric acid plants,
- natural gas fueled reciprocating engines,
- natural gas fueled turbine engines, and
- boiler, heater, or kiln units.

Stationary natural gas fueled engines (i.e., turbine and reciprocating engines) constitute the most significant industrial source of NOx emissions. These engines are found at a number of different facilities and in a number of different types of service. In general, they are used to drive the following types of devices:

- compressor units (primarily natural gas compressors),
- oil pumps,
- water pumps, and
- power generators.

Depending on the specific application of these devices, the driver engines may be operated on either a continuous or an intermittent basis, and often under fluctuating loadings. In addition, some units serve only a standby or backup role.

3.2.2 Source Characterization

3.2.2.1 Data Set. The data set that has been used to characterize the industrial sources of NOx is identical to that described previously in Section 2.3.1 for SO_2 sources. However, letter codes and abbreviations used in the NOx inventory are as presented in Tables 3A to 3F.

3.2.2.2 Emission Rate Calculation and Analysis. As with SO_2 emission sources, industrial sources of NOx do not necessarily operate on a continuous basis or follow a uniform operating pattern, nor do the rates of emission necessarily remain constant during the periods of operation.

Table 3A. NOx inventory (industrial sources): types of industry sectors and facilities, and their respective codes.

Industry	Industry Code	Facility	Facility Code
1. Cement	CEM	Cement Plant	CEP
2. Chemical	CHE	Chemical Plant	CHP
3. Electric Utilities	ELE	Power Generation Plant	PGP
4. Fertilizer	FER	Fertilizer Plant	FP
5. Petroleum	PET	Gas Gathering System	GGS
		Sour Gas (Extraction) Plant	EGP
		Sour Gas (Flaring) Plant	FGP
		Sweet Gas Plant	GP
		Gas Transmission System	GTS
		Oil Battery	OB
		Oil Sands Plant	OSP
		Heavy Oil Plant	HOP
		Refinery	R
6. Pulp and Paper	PUL	Pulp and Paper Mill	PPM

Table 3B. NOx inventory (industrial sources): types of emission sources and their respective codes.

Source Type	Code
Boiler unit	BOILER
Heater unit	HEATER
Kiln	KILN
Nitric acid plant	NITRIC
Reciprocating engine	RECIP
Turbine engine	TURB

Table 3C. NOx inventory (industrial sources): qualifier code.

Description	Code
Compressor Unit	COMP
Power generation unit	GEN
Refrigeration unit	REF

Table 3D. NOx inventory (industrial sources): types of emission source operating modes and their respective codes.

Operating Mode	Code
Continuous	CON
Emergency	EMR
Not currently operating	NCO
Standby	STB
Suspended	SUS
To-be-constructed	TBC

Table 3E. NOx inventory (industrial sources): types of emission drivers and their respective codes.

Driver Type	Units	Code
Coal consumed.	Tonnes consumed per day (t/d).	C
Electrical power generated.	Millions of kilowatt-hours generated per day (GW•h/d).	E
NOx emissions appeared to be independent of any operating parameters; therefore, no driver was used.	Dimensionless.	N
Rated power output.	Kilowatts (kW).	P

Table 3F. NOx inventory (industrial sources): methods used to evaluate the emission factors.

Method of Evaluation	Code
Estimated by taking the average of emission factors available for similar sources	EST
Evaluated based on available emission data	EVA
Assumed to be equal to the value presented by the U.S. EPA for the type of emission source being considered	EPA

To estimate the actual rates of NOx emission for each source, emission factors have been employed. For natural gas fueled turbine and reciprocating engines it has been assumed that the probable rate of NOx emission may be approximated by the expression:

$$ER = MP \cdot LF \cdot TE \cdot EF \cdot OT \cdot 24 \times 10^{-12} \qquad [5]$$

where,

ER = NOx emission rate, t/d

MP = maximum rated power output, kW

LF = load factor

TE = thermodynamic efficiency factor, kJ/kW • h

EF = emission factor, ng/J

OT = operating-time factor (i.e., an OT value of 1.0 indicates that the emission source is operating 100% of the time).

The values for MP were obtained from the ERCB, the Standards and Approvals Division of Alberta Environment, and a compressor station survey prepared by Legge and Baker (1987). Contact was also made with several operating companies. Based on previous operating experience and the discussions with the operating companies, representative LF values for reciprocating and turbine engines are estimated to be 0.65 and 0.75, respectively.

A summary of the various TE values used to reflect typical thermodynamic efficiencies for the industrial engines is presented in Table 4.

A summary of the OT values which have been applied in the inventory to active industrial NOx emission sources (i.e., those sources which were identified as having an operating status), is presented in Table 5. Those sources which were identified as having a standby (STB), emergency (EMR), to-be-constructed (TBC), or suspended (SUS) status were assumed to have an OT value of zero.

Representative EF values for reciprocating and turbine engines in Alberta were determined to be 1,075 ng/J and 107 ng/J, respectively, based on the results of the source sampling program that was conducted. Details of the program are presented in Section 3.2.3.

To estimate NOx emissions from natural gas fueled boilers and heaters, equation (5) was again utilized. In the absence of available emission and operating data, an emission factor of 99 ng/J (U.S. EPA 1985) was used, and a representative load factor was judged to be 0.70. The TE values used are shown in Table 4, and the OT values are shown in Table 5.

To estimate actual emissions from large power boilers, the following equation was employed:

$$ER = EF \cdot E \qquad [6]$$

where,

E = electrical power generated, GW • h/day,

EF = emission factor, t/GW • h.

Table 4. Thermodynamic efficiencies of natural gas fueled equipment.

Source Type	MP (kW)	TE (kJ/kW • h)	Overall Thermodynamic Efficiency (%)
Reciprocating Engines	<325	12860[1]	28[1]
	325 to 600	11250[1]	32[1]
	≥600 to 2250	10000[1]	36[1]
	2250	9475[1]	38[1]
Turbine Engines	All	12860[2]	28[2]
Boiler and Heater Units	<375	5145[3]	70[3]
	≥375	4500[3]	80[3]

[1] Adapted from Perry and Chilton (1973).

[2] Estimated based on a review of performance curves available for several arbitrarily selected gas turbine units.

[3] Adapted from Baumeister et al. (1978).

Table 5. Average operating times of active industrial NOx emission sources.

Source Type	Service	OT Factor
Reciprocating engines	Natural gas compressors and pumping units	0.79[1]
Turbine engines	Natural gas compressors and pumping units	0.81[1]
Turbine and reciprocation engines	Refrigeration units	0.83[1]
Electric motors	All applications	0.85[1]
Heaters and boiler units	All applications	0.90[2]

[1] Mean value of data collected Legge and Baker (1987).

[2] Arbitrarily determined based on previous operating experience.

Incinerator stacks in general were not considered to be a significant source of NOx emissions. This was confirmed by results of the source sampling program (see Section 3.2.3).

The same type of precision analysis that was applied to the SO_2 emission sources has been applied to the industrial NOx emission sources (refer to Section 2.3.2).

3.2.3 Source Sampling Program

As mentioned in Section 3.1.1, a source sampling program was conducted to establish Alberta-specific NOx emission factors for the more significant types of stack sources for which suitable emission data were unavailable. A total of 22 emission sources were surveyed: 12 reciprocating engines, six turbine engines, and four incinerator stacks.

In Tables 6 and 7, determined emission factors are presented for each of the tested reciprocating and turbine engines. Detailed results of the individual tests are presented in Volume 4, Sections 2.1 and 2.2. More reciprocating engines than turbine engines were tested because, after six of each type had been sampled, the reciprocating engines proved to have much greater variability in the determined emission factors. Therefore, to improve the reliability of the reciprocating engine data, it was appropriate to conduct additional testing. The large variability in the reciprocating engine emission factors appears to be primarily due to differences in the operating performance of the units. The best tuned engines (i.e., slight excess air) had the highest emission factors [see the individual test reports in Volume 4, Section 2.11], which is consistent with Zelensky (1983).

Based on averages of the emission factors presented in Tables 6 and 7, representative NOx emission factors for natural gas fueled reciprocating and turbine engines in Alberta are 1075 ng/J (precision = 1.101) and 107 ng/J (precision = 0.422), respectively. A comparison of these values with corresponding U.S. EPA (1985) values is presented in Table 8. Considering the precision of the determined emission factors, agreement with U.S. EPA values is quite good.

As there had been some concern that waste gas incinerator units might be significant sources of NOx emissions (i.e., produce NOx emissions at a rate greater than or equal to that of a typical 100 kW engine), four incinerator stacks were sampled. Incinerator stacks from one small, one medium and two large sulphur recovery units (i.e., in the order of 10, 100 and 1000 t/d of sulphur recovery capacity) were tested. A summary of the results from the four tests is presented in Table 9; detailed results for each of the tests are presented in Sections 1 and 2.3 of Volume 4. Although a relatively high NOx emission rate occurred for one of the incinerator units (0.061 t/d), the test results indicate that NOx emissions from a single waste gas incinerator unit will generally be no greater than that which may result from a 100 kW natural gas fueled reciprocating engine (roughly 0.03 t/d). Therefore, waste gas incinerator units are not, in general, considered to be noteworthy point sources of NOx emissions.

3.2.4 Sample of the Inventory

A sample of the inventory of industrial sources of NOx emissions is presented in Figure 4. The field headings which appear in Figure 4 are defined in Table 10. All letter codes and abbreviations that have been used in the inventory are defined in Tables 3A to 3G.

Table 6. NOx emission factors determined for natural gas fueled reciprocating engines in Alberta, 1985 October 7 to 1986 February 12.

Test Number	Maximum Rated Power Output (kW)	Determined Emission Factor (ng/J)
1	600	84
2	820	2,797
3	600	148
4	895	83
5	480	323
6	1,200	715
7	1,500	719
8	820	218
9	930	3,412
10	1,500	2,554
11	1,120	1,341
12	1,120	504

Average Emission Factor = 1075 ng/J

Emission Factor Precision = 1.101

Note: When characterizing a class of emission sources in terms of a single representative emission factor, the normal practice is to take the average of available data and indicate the precision of these data as has been done above. The use of this approach implies that the data are normally distributed. The data presented here, however, are not normally distributed, as indicated by the quoted precision which implies that some 20% of all values are negative. Use of the average value may therefore be inappropriate. Alternatively, the geometric mean is 540 ng/J, the median is about 610 ng/J.

Table 7. NOx emission factors determined for natural gas fueled turbine engines in Alberta, 1985 November 14 to 1986 January 13.

Test Number	Maximum Rated Power Output (kW)	Determined Emission Factor (ng/J)
1	18,540	124
2	17,310	123
3	9,025	47
4	25,975	73
5	8,690	98
6	2,650	176

Average Emission Factor = 107 ng/J

Emission Factor Precision = 0.422

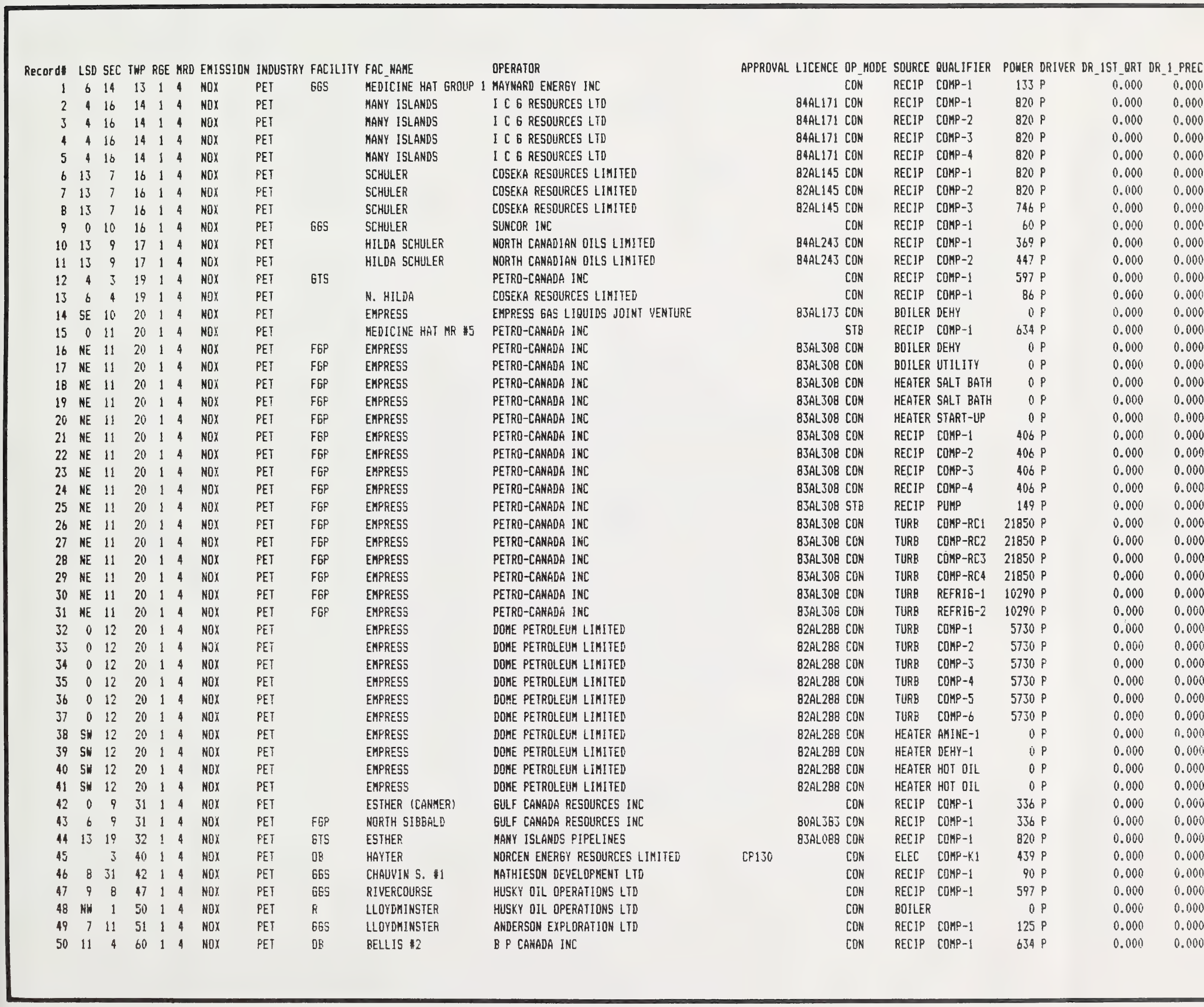
Table 8. A comparison of the NOx emission factor values determined for natural gas fueled engines in Alberta, and those presented by the U.S. EPA.

Description	U.S. EPA Value[1] (ng/J)	Alberta Value (ng/J)	Percent Deviation from EPA Value
Turbine Engines	126	107	15%
Reciprocating Engines	1481	1075	27%

[1] Source: U.S. Environmental Protection Agency (1985).

Table 9. NOx emission rates and the mass ratio of NOx to SO_2 emissions determined for waste gas incinerator units in Alberta, 1985 August 21 to December 12.

Sulphur Recovery Plant Size (t/d)	NOx Emission Rate (t/d)	Mass Ratio of NOx/SO_2 Emissions
10	0.0198	0.00347
170	0.0093	0.00189
1200	0.0337	0.00108
1800	0.0610	0.00123



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Record# LSD SEC TWP RGE MRD EMISSION INDUSTRY FACILITY FAC_NAME             OPERATOR                             APPROVAL LICENCE OP_MODE SOURCE QUALIFIER  POWER DRIVER DR_1ST_QRT DR_1_PREC
      1   6  14  13   1   4 NOX      PET      GGS      MEDICINE HAT GROUP 1 MAYNARD ENERGY INC                                    CON     RECIP  COMP-1       133 P           0.000     0.000
      2   4  16  14   1   4 NOX      PET               MANY ISLANDS         I C G RESOURCES LTD                           84AL171 CON     RECIP  COMP-1       820 P           0.000     0.000
      3   4  16  14   1   4 NOX      PET               MANY ISLANDS         I C G RESOURCES LTD                           84AL171 CON     RECIP  COMP-2       820 P           0.000     0.000
      4   4  16  14   1   4 NOX      PET               MANY ISLANDS         I C G RESOURCES LTD                           84AL171 CON     RECIP  COMP-3       820 P           0.000     0.000
      5   4  16  14   1   4 NOX      PET               MANY ISLANDS         I C G RESOURCES LTD                           84AL171 CON     RECIP  COMP-4       820 P           0.000     0.000
      6  13   7  16   1   4 NOX      PET               SCHULER              COSEKA RESOURCES LIMITED                      82AL145 CON     RECIP  COMP-1       820 P           0.000     0.000
      7  13   7  16   1   4 NOX      PET               SCHULER              COSEKA RESOURCES LIMITED                      82AL145 CON     RECIP  COMP-2       820 P           0.000     0.000
      8  13   7  16   1   4 NOX      PET               SCHULER              COSEKA RESOURCES LIMITED                      82AL145 CON     RECIP  COMP-3       746 P           0.000     0.000
      9   0  10  16   1   4 NOX      PET      GGS      SCHULER              SUNCOR INC                                            CON     RECIP  COMP-1        60 P           0.000     0.000
     10  13   9  17   1   4 NOX      PET               HILDA SCHULER        NORTH CANADIAN OILS LIMITED                   84AL243 CON     RECIP  COMP-1       369 P           0.000     0.000
     11  13   9  17   1   4 NOX      PET               HILDA SCHULER        NORTH CANADIAN OILS LIMITED                   84AL243 CON     RECIP  COMP-2       447 P           0.000     0.000
     12   4   3  19   1   4 NOX      PET      GTS                           PETRO-CANADA INC                                      CON     RECIP  COMP-1       597 P           0.000     0.000
     13   6   4  19   1   4 NOX      PET               N. HILDA             COSEKA RESOURCES LIMITED                              CON     RECIP  COMP-1        86 P           0.000     0.000
     14  SE  10  20   1   4 NOX      PET               EMPRESS              EMPRESS GAS LIQUIDS JOINT VENTURE             83AL173 CON     BOILER DEHY           0 P           0.000     0.000
     15   0  11  20   1   4 NOX      PET               MEDICINE HAT MR #5   PETRO-CANADA INC                                      STB     RECIP  COMP-1       634 P           0.000     0.000
     16  NE  11  20   1   4 NOX      PET      FGP      EMPRESS              PETRO-CANADA INC                              83AL308 CON     BOILER DEHY           0 P           0.000     0.000
     17  NE  11  20   1   4 NOX      PET      FGP      EMPRESS              PETRO-CANADA INC                              83AL308 CON     BOILER UTILITY        0 P           0.000     0.000
     18  NE  11  20   1   4 NOX      PET      FGP      EMPRESS              PETRO-CANADA INC                              83AL308 CON     HEATER SALT BATH      0 P           0.000     0.000
     19  NE  11  20   1   4 NOX      PET      FGP      EMPRESS              PETRO-CANADA INC                              83AL308 CON     HEATER SALT BATH      0 P           0.000     0.000
     20  NE  11  20   1   4 NOX      PET      FGP      EMPRESS              PETRO-CANADA INC                              83AL308 CON     HEATER START-UP       0 P           0.000     0.000
     21  NE  11  20   1   4 NOX      PET      FGP      EMPRESS              PETRO-CANADA INC                              83AL308 CON     RECIP  COMP-1       406 P           0.000     0.000
     22  NE  11  20   1   4 NOX      PET      FGP      EMPRESS              PETRO-CANADA INC                              83AL308 CON     RECIP  COMP-2       406 P           0.000     0.000
     23  NE  11  20   1   4 NOX      PET      FGP      EMPRESS              PETRO-CANADA INC                              83AL308 CON     RECIP  COMP-3       406 P           0.000     0.000
     24  NE  11  20   1   4 NOX      PET      FGP      EMPRESS              PETRO-CANADA INC                              83AL308 CON     RECIP  COMP-4       406 P           0.000     0.000
     25  NE  11  20   1   4 NOX      PET      FGP      EMPRESS              PETRO-CANADA INC                              83AL308 STB     RECIP  PUMP         149 P           0.000     0.000
     26  NE  11  20   1   4 NOX      PET      FGP      EMPRESS              PETRO-CANADA INC                              83AL308 CON     TURB   COMP-RC1   21850 P           0.000     0.000
     27  NE  11  20   1   4 NOX      PET      FGP      EMPRESS              PETRO-CANADA INC                              83AL308 CON     TURB   COMP-RC2   21850 P           0.000     0.000
     28  NE  11  20   1   4 NOX      PET      FGP      EMPRESS              PETRO-CANADA INC                              83AL308 CON     TURB   COMP-RC3   21850 P           0.000     0.000
     29  NE  11  20   1   4 NOX      PET      FGP      EMPRESS              PETRO-CANADA INC                              83AL308 CON     TURB   COMP-RC4   21850 P           0.000     0.000
     30  NE  11  20   1   4 NOX      PET      FGP      EMPRESS              PETRO-CANADA INC                              83AL308 CON     TURB   REFRIG-1   10290 P           0.000     0.000
     31  NE  11  20   1   4 NOX      PET      FGP      EMPRESS              PETRO-CANADA INC                              83AL308 CON     TURB   REFRIG-2   10290 P           0.000     0.000
     32   0  12  20   1   4 NOX      PET               EMPRESS              DOME PETROLEUM LIMITED                        82AL288 CON     TURB   COMP-1      5730 P           0.000     0.000
     33   0  12  20   1   4 NOX      PET               EMPRESS              DOME PETROLEUM LIMITED                        82AL288 CON     TURB   COMP-2      5730 P           0.000     0.000
     34   0  12  20   1   4 NOX      PET               EMPRESS              DOME PETROLEUM LIMITED                        82AL288 CON     TURB   COMP-3      5730 P           0.000     0.000
     35   0  12  20   1   4 NOX      PET               EMPRESS              DOME PETROLEUM LIMITED                        82AL288 CON     TURB   COMP-4      5730 P           0.000     0.000
     36   0  12  20   1   4 NOX      PET               EMPRESS              DOME PETROLEUM LIMITED                        82AL288 CON     TURB   COMP-5      5730 P           0.000     0.000
     37   0  12  20   1   4 NOX      PET               EMPRESS              DOME PETROLEUM LIMITED                        82AL288 CON     TURB   COMP-6      5730 P           0.000     0.000
     38  SW  12  20   1   4 NOX      PET               EMPRESS              DOME PETROLEUM LIMITED                        82AL288 CON     HEATER AMINE-1        0 P           0.000     0.000
     39  SW  12  20   1   4 NOX      PET               EMPRESS              DOME PETROLEUM LIMITED                        82AL288 CON     HEATER DEHY-1         0 P           0.000     0.000
     40  SW  12  20   1   4 NOX      PET               EMPRESS              DOME PETROLEUM LIMITED                        82AL288 CON     HEATER HOT OIL        0 P           0.000     0.000
     41  SW  12  20   1   4 NOX      PET               EMPRESS              DOME PETROLEUM LIMITED                        82AL288 CON     HEATER HOT OIL        0 P           0.000     0.000
     42   0   9  31   1   4 NOX      PET               ESTHER (CANMER)      GULF CANADA RESOURCES INC                             CON     RECIP  COMP-1       336 P           0.000     0.000
     43   6   9  31   1   4 NOX      PET      FGP      NORTH SIBBALD        GULF CANADA RESOURCES INC                     80AL363 CON     RECIP  COMP-1       336 P           0.000     0.000
     44  13  19  32   1   4 NOX      PET      GTS      ESTHER               MANY ISLANDS PIPELINES                        83AL088 CON     RECIP  COMP-1       820 P           0.000     0.000
     45       3  40   1   4 NOX      PET      OB       HAYTER               NORCEN ENERGY RESOURCES LIMITED       CP130             CON     ELEC   COMP-K1      439 P           0.000     0.000
     46   8  31  42   1   4 NOX      PET      GGS      CHAUVIN S. #1        MATHIESON DEVELOPMENT LTD                             CON     RECIP  COMP-1        90 P           0.000     0.000
     47   9   8  47   1   4 NOX      PET      GGS      RIVERCOURSE          HUSKY OIL OPERATIONS LTD                              CON     RECIP  COMP-1       597 P           0.000     0.000
     48  NW   1  50   1   4 NOX      PET      R        LLOYDMINSTER         HUSKY OIL OPERATIONS LTD                              CON     BOILER                0 P           0.000     0.000
     49   7  11  51   1   4 NOX      PET      GGS      LLOYDMINSTER         ANDERSON EXPLORATION LTD                              CON     RECIP  COMP-1       125 P           0.000     0.000
     50  11   4  60   1   4 NOX      PET      OB       BELLIS #2            B P CANADA INC                                        CON     RECIP  COMP-1       634 P           0.000     0.000
```

Figure 4. A sample of the NO_x inventory (industrial sources).

DR_1ST_QRT	DR_1_PREC	DR_2ND_QRT	DR_2_PREC	DR_3RD_QRT	DR_3_PREC	DR_4TH_QRT	DR_4_PREC	DR_YEAR	EF	EF_PREC	EF_YEAR	EF_SOURCE	ER_1ST_QRT	ER_1_PREC	ER_2ND_QRT
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.023	0.000	0.023
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.109	0.000	0.109
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.109	0.000	0.109
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.109	0.000	0.109
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.109	0.000	0.109
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.109	0.000	0.109
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.109	0.000	0.109
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.099	0.000	0.099
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.010	0.000	0.010
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.055	0.000	0.055
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.067	0.000	0.067
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.089	0.000	0.089
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.015	0.000	0.015
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		99.00000	0.000	1981	EPA	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		99.00000	0.000	1981	EPA	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		99.00000	0.000	1981	EPA	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		99.00000	0.000	1981	EPA	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		99.00000	0.000	1981	EPA	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		99.00000	0.000	1981	EPA	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.061	0.000	0.061
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.061	0.000	0.061
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.061	0.000	0.061
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.061	0.000	0.061
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		107.00000	0.422	1986	EVA	0.438	0.000	0.438
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		107.00000	0.422	1986	EVA	0.438	0.000	0.438
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		107.00000	0.422	1986	EVA	0.438	0.000	0.438
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		107.00000	0.422	1986	EVA	0.438	0.000	0.438
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		107.00000	0.422	1986	EVA	0.212	0.000	0.212
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		107.00000	0.422	1986	EVA	0.212	0.000	0.212
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		107.00000	0.422	1986	EVA	0.115	0.000	0.115
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		107.00000	0.422	1986	EVA	0.115	0.000	0.115
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		107.00000	0.422	1986	EVA	0.115	0.000	0.115
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		107.00000	0.422	1986	EVA	0.115	0.000	0.115
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		107.00000	0.422	1986	EVA	0.115	0.000	0.115
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		107.00000	0.422	1986	EVA	0.115	0.000	0.115
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		99.00000	0.000	1981	EPA	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		99.00000	0.000	1981	EPA	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		99.00000	0.000	1981	EPA	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		99.00000	0.000	1981	EPA	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.050	0.000	0.050
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.050	0.000	0.050
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.109	0.000	0.109
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.015	0.000	0.015
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.089	0.000	0.089
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.00000	0.000			0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.021	0.000	0.021
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1075.00000	1.101	1986	EVA	0.084	0.000	0.084

Table 10. NOx emission inventory (industrial sources): definition of the field headings.

Field Heading	Description
LSD	Legal subdivision in which the emission source is located.
SEC	Section in which the emission source is located.
TWP	Township in which the emission source is located.
RGE	Range in which the emission source is located.
MRD	Closest meridian located east of the emission source.
EMISSION	Type of emission (i.e., NOx or SO_2).
INDUSTRY	Industry sector with which the facility is associated (see Table 3A).
FACILITY	Type of facility of which the emission source is a part (see Table 3A).
FAC-NAME	Name of the facility.
OPERATOR	Name of the company which operates the facility.
APPROVAL	Approval number of facilities which have been approved by ERCB.
LICENCE	Licence number of facilities which have been licenced to operate under the Clean Air Act.
OP-MODE	Operating mode of the emission source (see Table 3D).

Continued...

Table 10 (continued).

Field Heading	Description
SOURCE	Type of emission source (see Table 3B).
QUALIFIER	A statement which serves to uniquely identify an emission source when more than one of the same type occur at the same facility.
POWER	Rated power output of the emission source, kW.
DRIVER	Type of emission driver (see Table 3E).
DR-1ST-QRT	Average daily value of the emission driver during the first quarter.
DR-1-PREC	Precision of the first-quarter driver rate.
DR-2ND-QRT	Average daily value of the emission driver during the second quarter.
DR-2-PREC	Precision of the second-quarter driver rate.
DR-3RD-QRT	Average daily value of the emission driver during the third quarter.
DR-3-PREC	Precision of the third-quarter driver rate.
DR-4TH-QRT	Average daily value of the emission driver during the fourth quarter.
DR-4-PREC	Precision of the fourth-quarter driver rate.

Continued...

Table 10 (continued).

Field Heading	Description
DR-YEAR	Year for which the driver rate values are presented.
EF	Emission factor.
EF-PREC	Precision of the emission factor.
EF-YEAR	Year in which the emission factor was determined.
EF-SOURCE	Method by which the emission factor was determined (see Table 3F).
ER-1ST-QRT	Average daily rate of NOx emission during the first quarter, t/d.
ER-1-PREC	Precision of first-quarter emission rate.
ER-2ND-QRT	Average daily rate of NOx emission during the second quarter, t/d.
ER-2-PREC	Precision of second-quarter emission rate.
ER-3RD-QRT	Average daily rate of NOx emission during the third quarter, t/d.
ER-3-PREC	Precision of the third-quarter emission rate.
ER-4TH-QRT	Average daily rate of NOx emission during the fourth quarter, t/d.
ER-4-PREC	Precision of the fourth-quarter emission rate.

Continued...

Table 10 (concluded).

Field Heading	Description
ER-AVERAGE	Average annual daily rate of NOx emission, t/d.
LIC-ER	Where applicable, the maximum licenced rate of emission, t/d.
OPR-TIME	The fraction of the time during which the emission source is operating (1.0 indicates continuous usage).
STACK-HT	Stack height, m.
STACK-DIA	Inside diameter at the stack outlet, m.
SITE-ELEV	Elevation of the site above sea level, m.
EXIT-VEL	Exit velocity of the stack effluent, m/s.
EXIT-TEMP	Exit temperature of the stack effluent, °C.
ECOREGION	Ecoregion (see Table 1H), in which the facility is located.
ENV-SETTING	Environmental setting (see Table 1G).

3.3 URBAN CENTRE SOURCES

3.3.1 Classification System

Each urban centre source has been classified according to the following types of urban centres, as identified by Alberta Municipal Affairs (1985):

- village,
- town, and
- city.

Typically, a village is an urban centre which has a population of approximately 100 to 1,000; a town has a population of approximately 1,000 to 10,000; and a city has a population of approximately 10,000 or more.

Summer villages (i.e., urban centres with a population of typically 100 or less) were considered too small to warrant identification as NOx emission sources, and rural populations were considered to be too diffuse.

3.3.2 Source Characterization

3.3.2.1 Data Set. The basic data set used to characterize urban centre sources of NOx is as follows:

1. Location - The location based on Alberta's legal land system (see Figures 1 and 2).
2. Type of Urban Centre - Village, Town or City.
3. Name - Name of the urban centre (e.g., Calgary, Red Deer, Olds).
4. Population - Population of the urban centre.
5. Area - The total land area within the corporate boundaries of the urban centre.
6. Emission Rate - The calculated rate of NOx emission.
7. Ecoregion - The ecoregion (see Table 1H) in which the urban centre is located.

3.3.2.2 Calculation of Emission Rates. Natural gas consumption (residential, commercial and industrial usage) and vehicular traffic are the primary sources of urban NOx emissions. Therefore, in order to evaluate NOx emissions for a specific urban centre, it is necessary to estimate the amount of natural gas consumed and amount of vehicular traffic for that particular urban centre.

In Alberta, natural gas is supplied to urban centres by either Northwestern Utilities Limited, Canadian Western Natural Gas Company Limited or one of a number of small natural gas cooperatives. Northwestern Utilities and Canadian Western Natural Gas provided 1984 consumption figures for 19 arbitrarily selected urban centres. These municipalities were:

Towns:

Bassano
Black Diamond
Bow Island
Camrose
Carstairs
Gleichen
Olds Whitecourt
Oyen
Peace River
Rocky Mountain House
Strathmore
Swan Hills
Vauxhall
Vermilion

Cities:

Calgary
Edmonton
Fort McMurray
Lethbridge

Using the data obtained for these municipalities, a set of natural gas consumption factors have been developed. These factors are shown in Table 11. The factors relate residential, commercial and industrial rates of natural gas consumption to urban population on a per-capita basis.

In developing Table 11 it was assumed that, in terms of per-capita consumption of natural gas,

- the average of the trends observed for Calgary and Edmonton are representative of those for Red Deer;
- the trends observed for Lethbridge are representative of those for Medicine Hat;
- the trends observed for Fort McMurray are representative of Grande Prairie and St. Albert;
- the average of the trends observed for Camrose, Oyen, Swan Hills, Peace River, Rocky Mountain House, Vermilion, and Whitecourt are representative of those for all urban centres north of Red Deer excepting Edmonton, Fort McMurray, Grande Prairie and St. Albert; and
- the average of the trends observed for Olds, Strathmore, Bow Island, Bassano, Carstairs, Vauxhall, Black Diamond, and Gleichen are representative of those for all urban centres south of Red Deer, excepting Calgary, Lethbridge, and Medicine Hat.

For a given urban centre, the annual consumption of natural gas has been estimated using the equation:

$$GC_i = CF_i \cdot P \qquad [7]$$

where

GC = annual consumption of natural gas in terajoules, TJ (10^{12} J);
CF = per-capita natural gas consumption factor (see Table 11), TJ/person; and
P = population (Alberta Municipal Affairs 1985).

Table 11. Annual per-capita natural gas consumption factors for urban centres in Alberta[1].

Urban Centre	I.D. Code	Residential (TJ/person)	Commercial (TJ/person)	Industrial (TJ/person)
Calgary	CAL	0.0478	0.0471	0.0154
Edmonton	EDM	0.0423	0.0581	0.0214
Red Deer	RED	0.0451	0.0526	0.0184
Lethbridge Medicine Hat	LMH	0.0456	0.0409	0.0203
Fort McMurray Grande Prairie St. Albert	FGS	0.0404	0.0372	0.0000
All others north of Red Deer	N	0.0462	0.0549	0.0067
All others south of Red Deer	S	0.0517	0.0398	0.0040

[1] Based on natural-gas consumption data provided by Northwestern Utilities Limited and Canadian Western Natural Gas Limited for the year 1984.

In equation [7], subscript i is used to denote commercial (COM), residential (RES) or industrial (IND) consumption of natural gas.

The rate at which NOx is emitted by each urban centre due to each type of natural gas consumption was estimated using the equation:

$$ER_i = 0.0727 \cdot EF_i \cdot GC_i \qquad [8]$$

where

ER = NOx emission rate in tonnes per day, t/d;
EF = emission factor, kg/m^3; and
i = COM, RES or IND.

The EF values for residential, commercial and industrial usage of natural gas were assumed to be 1,280, 1,920 and 1,920 kg/m^3, respectively, as adapted from U.S. EPA (1985).

Based on previous work by Western Research (1976 a,b), the ratio of annual NOx emissions that result from space heating to those that result from vehicular traffic is approximately 0.3 for the cities of Calgary and Edmonton. In evaluating this ratio, NOx emissions due to space heating were attributed to 85% of the nonindustrial natural gas usage. Here, these relationships were assumed to be representative of all urban centres in Alberta.

To determine NOx emissions due to vehicular traffic, the following equation was therefore used:

$$ER_{VEH} = \frac{0.85\ (ER_{COM} + ER_{RES})}{0.30} \qquad [9]$$

$$= 2.83\ (ER_{COM} + ER_{RES}) \qquad [10]$$

where subscript VEH denotes vehicular traffic.

Finally, the total NOx emission rate for each urban centre was determined by the relation:

$$ER = ER_{COM} + ER_{RES} + ER_{IND} + ER_{VEH} \qquad [11]$$

where the values of ER_{COM}, ER_{RES} and ER_{IND} are determined by equation [8], and ER_{VEH} is determined by equation [10].

3.3.3 Sample of the Inventory

A sample of the inventory of NOx emissions due to urban centres is presented in Figure 5. The field headings which appear in Figure 5 are defined in Table 12.

Record#	SEC	TWP	RGE	MRD	NAME	TYPE	AREA	POPULATION	POP_YR	URBAN_ID	ER_AVERAGE	ELEVATION	ECOREGION
1	12	27	1	5	AIRDRIE	CTY	1360.00	10431	1984	S	0.494	1082	3
2	6	24	1	5	CALGARY	CTY	52721.00	619814	1984	CAL	35.371	1058	3
3	34	46	20	4	CAMROSE	CTY	2460.00	12751	1984	N	0.713	675	4
4	1	29	20	4	DRUMHELLER	CTY	1615.00	6671	1984	S	0.316	687	2
5	1	53	25	4	EDMONTON	CTY	63066.00	560085	1984	EDM	36.479	658	4
6	16	89	9	4	FORT MCMURRAY	CTY	6007.37	35352	1984	FGS	1.371	369	8
7	24	71	6	6	GRAND PRAIRIE	CTY	4079.00	24411	1984	FGS	0.947	652	6
8	25	49	25	4	LEDUC	CTY	7416.00	12471	1984	N	0.697		4
9	31	8	21	4	LETHBRIDGE	CTY	6535.00	58586	1984	LMH	3.245	903	2
10	31	12	5	4	MEDICINE HAT	CTY	6272.00	41493	1984	LMH	2.298	717	1
11	21	38	27	4	RED DEER	CTY	5180.00	51070	1984	RED	3.121	860	4
12	3	54	25	4	ST. ALBERT	CTY	3560.00	35529	1984	FGS	1.378		4
13	14	46	24	4	WETASKIWIN	CTY	1130.00	10022	1984	N	0.560	756	4
14	16	66	22	4	ATHABASCA	TWN	1423.00	1862	1984	N	0.104	518	8
15	20	59	3	5	BARRHEAD	TWN	777.00	3849	1984	N	0.215	644	8
16	4	42	21	4	BASHAW	TWN	282.20	875	1984	N	0.049	792	4
17	17	21	18	4	BASSANO	TWN	483.60	1200	1984	S	0.057	800	2
18	26	50	24	4	BEAUMONT	TWN	370.00	3468	1984	N	0.194		4
19	2	72	10	6	BEAVERLODGE	TWN	495.00	1937	1984	N	0.108	732	8
20	8	20	2	5	BLACK DIAMOND	TWN	192.86	1545	1984	S	0.073		4
21	27	39	27	4	BLACKFALDS	TWN	255.32	1614	1984	N	0.090	875	4
22	12	56	24	4	BON ACCORD	TWN	203.31	1425	1984	N	0.080		4
23	18	61	5	4	BONNYVILLE	TWN	1211.96	4786	1984	N	0.267	549	8
24	35	10	11	4	BOW ISLAND	TWN	309.30	1499	1984	S	0.071	799	1
25	23	34	1	5	BOWDEN	TWN	122.03	1021	1984	S	0.048	915	4
26	32	18	14	4	BROOKS	TWN	1549.72	9421	1984	S	0.446	758	1
27	33	55	20	4	BRUDERHEIM	TWN	455.00	1238	1984	N	0.069	640	4
28	25	49	27	4	CALMER	TWN	192.00	1137	1984	N	0.064	716	4
29	32	24	10	5	CANMORE	TWN	1961.00	4012	1984	S	0.190	1309	6
30	9	3	25	4	CARDSTON	TWN	612.41	3546	1984	S	0.168	1166	3
31	17	30	1	5	CARSTAIRS	TWN	139.00	1725	1984	S	0.082		4
32	34	37	14	4	CASTOR	TWN	272.75	1123	1984	S	0.053	770	4
33	26	12	27	4	CLARESHOLM	TWN	524.69	3493	1984	S	0.165	1033	2
34	10	9	20	4	COAL DALE	TWN	442.42	4768	1984	S	0.226	862	2
35	3	26	4	5	COCHRANE	TWN	1800.00	4044	1984	S	0.191	1280	4
36	19	63	1	4	COLD LAKE	TWN	769.72	2515	1984	N	0.141	541	8
37	13	36	11	4	CORONATION	TWN	369.00	1268	1984	S	0.060	798	2
38	26	28	1	5	CROSSFIELD	TWN	371.50	1428	1984	S	0.068	1128	3
39	12	8	6	5	CROWSNEST PASS	TWN	14913.00	7577	1984	S	0.359		5
40	9	45	16	4	DAYSLAND	TWN	165.80	709	1984	N	0.040	689	4
41	34	50	26	4	DEVON	TWN	608.64	3931	1984	N	0.220		4
42	18	31	1	5	DIDSBURY	TWN	434.00	3286	1984	S	0.156	1006	4
43	18	49	7	5	DRAYTON VALLEY	TWN	745.00	4924	1984	N	0.275	860	9
44	16	39	3	5	ECKVILLE	TWN	119.40	842	1984	N	0.047	914	4
45	22	53	17	5	EDSON	TWN	2715.26	7110	1984	N	0.397	923	9
46	1	57	7	4	ELK POINT	TWN	194.24	1113	1984	N	0.062	600	4
47	34	81	3	6	FAIRVIEW	TWN	913.83	3234	1984	N	0.181	658	8
48	9	78	21	5	FALHER	TWN	265.85	1188	1984	N	0.066	582	8
49	12	9	26	4	FORT MACLEOD	TWN	1606.19	3139	1984	S	0.149	950	2
50	28	62	19	5	FOX CREEK	TWN	534.18	1978	1984	N	0.111	841	8

Figure 5. A sample of the NO_x inventory (urban centre sources).

Table 12. NOx inventory (urban sources): definition of the field headings.

Field Heading	Definition
SEC	Section in which the emission source is located.
TWP	Township in which the emission source is located.
RGE	Range in which the emission source is located.
MRD	Closest meridian located east of the emission source.
NAME	Designated name of the urban centre.
TYPE	Type of urban centre (i.e., city, town or village).
AREA	Total land area, ha.
POPULATION	Total population of the urban centre.
POP-YR	Year for which the population number is presented.
URBAN-ID	See Table 11.
ER-AVERAGE	Annual rate of NOx emission, t/d.
ELEVATION	Elevation above sea level, m.
ECOREGION	Ecoregion (see Table 1H), in which the urban centre is located.

3.4 HIGHWAY SOURCES

3.4.1 Classification System

As previously mentioned, Highways 1 and 16, and Highway 2 from Westlock (located approximately 70 km north of Edmonton), south to the U.S. border, have been treated as noteworthy sources of NOx emissions. Each of these sections of highway has been divided into a number of short segments.

For cataloguing purposes, each segment has been classified by highway and by its location along that highway. For Highways 1 and 16, the location numbering begins at the Alberta/British Columbia border and ends at the Alberta/Saskatchewan border. For Highway 2, it begins at the U.S. border and ends near Westlock, approximately 70 km north of Edmonton.

3.4.2 Source Characterization

3.4.2.1 Data Set. The basic data set used to characterize each highway segment and the NOx emissions associated with it is:

1. Highway - The number of the highway of which the segment is a part.
2. Segment - The numbered location of the segment.
3. Location - The names of the intersections at which the segment begins and ends.
4. Length - Approximate length of the segment.
5. Vehicle Volume - The average daily volume of traffic.
6. Vehicle Distribution - A percentage breakdown of the total vehicle volume based on the following vehicle types:
   - passenger vehicles (PV),
   - recreation vehicles (RV),
   - buses (B),
   - single unit trucks (SUT), and
   - tractor trailer units (TTU).
7. Year - The year for which the vehicle volume and distribution data are presented.
8. Emission Rate - The calculated rate of NOx emission in tonnes per day (t/d).
9. Ecoregion - The ecoregion in which the segment is primarily located (see Table 1h).

3.4.2.2 Calculation of Emission Rates. The rate at which NOx is emitted from each segment of each highway was estimated for each quarter of the year using the equation,

$$ER_{HYWj} = \sum_i VV_i \cdot EF_{i,j} \cdot L_i \; 10^6 \qquad [12]$$

where,

ER_{HYW} = NOx emission rate, t/d;

VV = average annual daily vehicle volume (Alberta Transportation 1985), vehicles per day;

EF = NOx emission factor (see Table 13), g/km;

L = length of the segment, km;

i = Alberta transportation motor vehicle category (i.e., passenger vehicles, recreation vehicles, buses, single unit trucks or tractor trailer combinations); and

j = time period (i.e. first, second, third or fourth quarter of the year).

The EF values used are presented in Table 14. These values were adapted from values developed by Industrial Programs Branch, Environmental Protection Service, Environment Canada (Environment Canada, Environmental Protection Service, letter 1985) using a Canadian version of the U.S. EPA Federal Test Procedure and Mobile 3. In applying Mobile 3, Environment Canada assumed that,

1. the average highway speed of Alberta motor vehicles is approximately 88 km/h (55 mph).
2. The average frequency distribution of motor vehicle types on Alberta highways is closely approximated by the vehicle type and fleet penetration averages for the calendar year 1984.
3. The following temperatures are indicative of quarterly temperature averages in the province of Alberta:

First Quarter (January 1 to March 31)	-12°C (11°F)
Second Quarter (April 1 to June 30)	3°C (37°F)
Third Quarter (July 1 to September 30)	15°C (59°F)
Fourth Quarter (October 1 to December 31)	4°C (39°F)

These temperature values were determined by Western Research, based on a review of Alberta climate normals for the period 1951 to 1980 (Environment Canada, 1982).

3.4.3 Sample of the Inventory

A sample of the inventory is presented in Figure 6. The field headings that appear in Figure 6 are defined in Table 14.

Table 13. NOx emission factors for Alberta motor vehicles, g/km[1].

Alberta Transportation Motor Vehicle Category	Code	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
Passenger Vehicles	PV	3.06	2.73	2.49	2.71
Recreation Vehicles	RV	3.95	3.59	3.34	3.57
Buses	B	5.96	5.60	5.33	5.57
Single Unit Trucks	SUT	5.96	5.60	5.33	5.57
Tractor Trailer Units	TTU	17.70	17.70	17.70	17.70

[1] The NOx emission factors presented in this table have been adapted from 1984 estimates provided by Industrial Programs Branch, Environmental Protection Service, Environment Canada.

Record#	HIGHWAY	SEG_NO	FROM_LOC	TO_LOC	LENGTH	ECOREGION	PV_W	RV_W	BUSES_W	SUT_W	TRT_W	AADT_W	PV_E	RV_E	BUSES_E	SUT_E	TRT_E	AADT_E	YEAR	CAR_S
1	1	1	BC/ALTA BORDER	1 & 1A NW OF CANMORE	82.5	5	78.0	14.3	1.1	1.7	4.8	9060	77.2	15.0	0.9	1.3	5.5	7090	1984	1
2	1	2	1 & 1A NW OF CANMORE	1 & 1A S OF CANMORE	53.5	5	77.1	15.6	1.0	1.4	4.9	7240	78.0	15.0	1.0	1.7	4.3	8120	1984	1
3	1	3	1 & 1A S OF CANMORE	1 1X S OF SEEBE	45.0	5	80.4	14.6	0.9	1.2	2.9	8340	78.4	14.2	0.8	1.8	4.8	8730	1984	1
4	1	4	1 & 1X S OF SEEBE	1 & 40 E OF SEEBE	3.0	5	76.9	13.5	1.1	2.3	6.2	8980	77.5	13.2	1.0	2.1	6.1	9320	1984	1
5	1	5	1 & 40 E OF SEEBE	1 & 968 SE OF MORLEY	51.5	5	78.0	13.2	0.6	2.4	5.8	8860	78.1	13.0	0.6	2.4	5.8	8920	1983	1
6	1	6	1 & 968 SE OF MORLEY	1 & 22 S OF COCHRANE	17.2	4	76.7	14.7	1.0	2.8	4.9	9690	78.6	13.2	0.9	2.8	4.4	10050	1984	1
7	1	7	1 & 22 S OF COCHRANE	1 & 563 W OF CALGARY	11.6	4	82.1	11.7	0.7	1.5	3.9	12700	82.2	11.2	0.7	2.2	3.8	13460	1984	1
8	1	8	1 & 563 W OF CALGARY	1 & 999 NE 32-24-2 W5M	5.1	4	75.4	18.6	0.8	2.0	3.2	15060	74.3	18.5	0.7	3.0	3.5	16110	1983	1
9	1	9	1 & 999 NE 32-24-2 W5M	1 & 789 E OF CALGARY NA	22.0	3	77.8	14.8	0.4	3.0	4.0	7090	77.6	15.1	0.4	2.8	4.2	6850	1979	
10	1	10	1 & 789 E OF CALGARY NA	1 & 1A E OF CALGARY	9.0	3	79.8	9.1	0.5	3.8	6.7	8530	83.3	9.8	0.6	3.0	3.3	6710	1984	1
11	1	11	1 & 1A E OF CALGARY	1 & 791 S OF DELACOUR	3.8	3	82.4	7.4	0.7	2.5	6.4	8460	82.4	7.6	0.7	2.6	6.7	8280	1984	1
12	1	12	1 & 791 S OF DELACOUR	1 & 9 & 797 N OF LANGDON	6.5	4	82.7	2.1	0.7	4.1	10.3	8160	81.8	2.1	0.5	4.5	11.2	7880	1984	1
13	1	13	1 & 9 & 797 N OF LANGDON	1 & 24 W OF STRATHMORE	10.0	4	77.4	7.6	0.3	5.1	9.6	8120	79.4	7.1	0.3	5.2	8.0	7210	1983	1
14	1	14	1 & 24 W OF STRATHMORE	1 & 817 AT STRATHMORE	9.7	4	78.7	6.5	0.6	6.3	7.9	7370	76.3	7.3	0.9	6.6	8.9	5990	1983	1
15	1	15	1 & 817 AT STRATHMORE	1 & 21 E OF STRATHMORE	9.7	2	81.5	6.8	0.5	2.8	8.4	5010	82.0	6.9	0.6	2.6	7.9	4430	1982	1
16	1	16	1 & 21 E OF STRATHMORE	1 & 561 E OF STRATHMORE	12.8	2	74.0	3.6	0.8	6.4	15.2	4800	72.0	4.2	1.0	5.3	17.5	3950	1984	1
17	1	17	1 & 561 E OF STRATHMORE	1 & 547 N OF GLEICHEN	17.3	2	74.9	6.7	1.2	4.2	13.0	3820	73.5	7.4	0.9	3.6	14.6	3320	1983	1
18	1	18	1 & 547 N OF GLEICHEN	1 & 842 N OF CLUNY	14.0	2	71.6	14.6	1.0	2.2	10.6	3320	70.4	15.1	1.2	2.4	10.9	3150	1982	1
19	1	19	1 & 842 N OF CLUNY	1 & 56 N OF CROWFOOT	15.8	2	72.4	7.9	1.1	4.3	14.4	3260	72.7	8.1	1.1	4.0	14.1	3340	1984	1
20	1	20	1 & 56 N OF CROWFOOT	1 & 847 AT BASSANO	19.2	2	65.8	18.1	0.7	4.5	10.8	3800	67.1	17.4	0.7	4.4	10.4	4150	1983	1
21	1	21	1 & 847 AT BASSANO	1 & 550 E OF BASSANO	3.6	2	64.4	18.9	0.7	4.2	11.9	4730	66.5	17.9	0.6	4.3	10.7	4250	1982	1
22	1	22	1 & 550 E OF BASSANO	1 & 36 W OF BROOKS	34.1	1	59.9	18.3	0.5	8.1	13.2	3790	59.6	18.2	0.5	0.2	13.4	3760	1983	1
23	1	23	1 & 36 W OF BROOKS	1 & 873 N OF BROOKS	8.2	1	69.5	13.9	0.7	5.4	10.4	3650	64.6	15.7	0.7	6.5	12.4	2590	1984	1
24	1	24	1 & 873 N OF BROOKS	1 & 542 E OF BROOKS	3.2	1	67.4	0.6	0.5	10.6	20.9	3580	78.2	0.5	0.5	7.2	13.6	5330	1983	1
25	1	25	1 & 542 E OF BROOKS	1 & 875 SE OF BROOKS	8.9	1	70.4	13.3	0.7	5.9	9.8	3880	68.7	14.9	0.8	5.3	10.3	3460	1983	1
26	1	26	1 & 875 SE OF BROOKS	1 & 876 N OF TILLEY	8.6	1	71.6	9.9	1.0	5.9	11.5	3060	68.1	11.6	1.1	6.0	13.3	2680	1984	1
27	1	27	1 & 876 N OF TILLEY	1 & 884 W OF SUFFIELD	45.5	1	69.0	19.9	1.1	3.3	6.7	2970	72.2	17.1	1.4	3.6	5.8	3550	1983	1
28	1	28	1 & 884 W OF SUFFIELD	1 & 999 NW 7-14-7 W4M	16.6	1	70.4	13.9	1.1	5.5	9.1	3610	70.7	13.8	1.1	5.3	9.1	3620	1983	1
29	1	29	1 & 999 NW 7-14-7 W4M	1 & 524 NW OF REDCLIFF	10.5	1	71.8	8.7	1.8	7.4	10.3	3680	70.7	8.5	1.8	8.3	10.6	3840	1984	1
30	1	30	1 & 524 NW OF REDCLIFF	1 & 999 NW 16-12-5 W4M	20.8	1	71.2	13.8	0.5	9.1	5.4	5040	70.0	14.6	0.4	9.4	5.6	4840	1983	1
31	1	31	1 & 999 NW 16-12-5 W4M	1 & 41 E OF DUNMORE WJ	5.6	1	68.0	21.6	0.3	4.3	5.9	3620	67.6	23.0	0.3	3.4	5.6	3330	1983	1
32	1	32	1 & 41 E OF DUNMORE WJ	1 & 41 W OF IRVINE EJ	18.5	1	68.5	22.1	0.3	3.4	5.7	3130	68.9	21.9	0.4	2.7	6.1	2650	1983	1
33	1	33	1 & 41 W OF IRVINE EJ	ALTA/SASK BORDER	24.5	1	68.5	22.1	0.3	3.4	5.7	3130	68.9	21.9	0.4	2.7	6.1	2650	1983	1
34	2	1	U.S./ALTA BORDER	2 & 501 S OF CARDSTON SJ	21.0	3	75.9	16.7	0.2	5.4	1.8	890	76.9	17.6	0.2	4.3	1.0	1430	1984	
35	2	2	2 & 501 S OF CARDSTON SJ	2 & 5 N OF CARDSTON NJ	4.2	3	77.3	16.7	0.3	3.5	2.2	3430	74.4	18.5	0.4	4.2	2.5	2010	1984	
36	2	3	2 & 5 N OF CARDSTON NJ	2 & 505 N OF CARDSTON SJ	15.9	3	72.8	11.9	0.6	10.8	4.0	1540	73.2	11.8	0.6	11.1	3.3	1460	1984	
37	2	4	2 & 505 N OF CARDSTON SJ	2 & 505 N OF CARDSTON NJ	3.0	3	69.3	25.0	0.4	4.1	1.2	1600	69.4	25.0	0.4	4.0	1.2	1650	1982	
38	2	5	2 & 505 N OF CARDSTON NJ	2 & 999 SW 9-6-25 W4M	8.2	3	83.0	7.9	4.2	3.4	1.6	1750	81.5	8.1	4.1	4.7	1.6	1690	1983	
39	2	6	2 & 999 SW 9-6-25 W4M	2 & 509 S OF STAND OFF	2.0	3	79.8	8.0	3.8	5.6	2.8	1810	79.1	8.5	2.4	6.0	4.1	1410	1982	
40	2	7	2 & 509 S OF STAND OFF	2 & 511 N OF STAND OFF	19.0	2	76.5	9.3	3.4	8.3	2.6	1270	77.0	8.7	3.2	8.0	3.0	1350	1983	
41	2	8	2 & 511 N OF STAND OFF	2 & 3 AT FT MACLEOD EJ	9.6	2	75.8	16.5	0.3	3.9	3.6	1520	0.0	0.0	0.0	0.0	0.0	0	1984	
42	2	9	2 & 3 AT FT MACLEOD EJ	2 &3 &810 W OF FT MACLEOD	4.0	2	65.6	20.2	0.7	4.9	8.6	4150	65.7	20.2	0.7	4.9	8.6	4150	1982	
43	2	10	2 &3 &810 W OF FT MACLEOD	2 & 785 W OF FT MACLEOD	2.5	2	66.8	19.3	0.6	4.2	9.1	4100	66.2	20.1	0.7	3.7	9.4	3810	1982	
44	2	11	2 & 785 W OF FT MACLEOD	2 & 519 W OF GRANUM	18.0	2	65.3	20.7	0.8	3.8	9.4	3370	66.5	16.7	0.6	3.9	12.3	4520	1984	
45	2	12	2 & 519 W OF GRANUM	2 & 520 AT CLARESHOLM	16.6	2	72.2	10.0	1.4	5.1	11.4	5180	80.7	7.6	0.9	3.9	6.9	8790	1983	
46	2	13	2 & 520 AT CLARESHOLM	2 & 2A AT STAVELY	17.0	3	70.0	9.1	0.6	4.7	15.6	4520	69.8	9.1	0.7	4.5	15.8	4510	1983	
47	2	14	2 & 2A AT STAVELY	2 & 529 S OF PARKLAND	9.8	3	73.6	13.8	0.6	2.4	9.5	4010	73.6	13.8	0.6	2.5	9.4	4040	1982	
48	2	15	2 & 529 S OF PARKLAND	2 & 2A W OF PARKLAND	0.6	3	66.6	11.1	0.9	5.0	16.4	4390	67.1	11.0	1.0	4.9	16.0	4500	1983	
49	2	16	2 & 2A W OF PARKLAND	2 & 533 S OF NANTON SJ	13.0	3	67.9	15.4	0.6	2.8	13.2	4940	70.2	14.0	0.5	3.6	11.7	5400	1984	
50	2	17	2 & 533 S OF NANTON SJ	2 & 533 AT NANTON NJ URB	2.0	3	76.6	10.9	0.4	4.6	7.5	5000	74.3	11.7	0.4	5.1	8.4	4400	1982	

Figure 6. A sample of the NO_x inventory (highway sources).

T_E	AADT_E	YEAR	CAR_SPD	TRK_SPD	ER_1ST_QRT	ER_2ND_QRT	ER_3RD_QRT	ER_4TH_QRT	ER_AVERAGE
5.5	7090	1984	100	100	5.340	4.917	4.611	4.891	4.938
4.3	8120	1984	100	100	3.239	2.976	2.785	2.960	2.988
4.8	8730	1984	110	100	2.937	2.689	2.510	2.674	2.701
6.1	9320	1984	110	100	0.229	0.212	0.199	0.211	0.213
5.8	8920	1983	110	100	3.764	3.476	3.267	3.458	3.490
4.4	10050	1984	110	100	1.349	1.240	1.162	1.234	1.246
3.8	13460	1984	110	100	1.153	1.055	0.985	1.050	1.060
3.5	16110	1983	110	100	0.606	0.554	0.517	0.551	0.557
4.2	6850	1979	50	50	1.193	1.094	1.023	1.088	1.099
3.3	6710	1984	100	100	0.551	0.508	0.476	0.505	0.510
6.7	8280	1984	100	100	0.265	0.246	0.231	0.244	0.246
1.2	7880	1984	100	100	0.500	0.469	0.446	0.467	0.470
8.0	7210	1983	100	100	0.702	0.655	0.621	0.652	0.657
8.9	5990	1983	100	100	0.590	0.550	0.521	0.548	0.552
7.9	4430	1982	100	100	0.404	0.376	0.356	0.374	0.377
7.5	3950	1984	100	100	0.635	0.604	0.581	0.602	0.605
4.6	3320	1983	100	100	0.652	0.616	0.591	0.614	0.618
0.9	3150	1982	100	100	0.441	0.413	0.394	0.412	0.415
4.1	3340	1984	100	100	0.560	0.530	0.508	0.528	0.532
0.4	4150	1983	100	100	0.750	0.704	0.671	0.702	0.707
10.7	4250	1982	100	100	0.163	0.153	0.146	0.152	0.153
13.4	3760	1983	100	100	1.334	1.262	1.210	1.258	1.266
12.4	2590	1984	100	100	0.257	0.242	0.231	0.241	0.242
13.6	5330	1983	100	100	0.164	0.156	0.150	0.155	0.156
10.3	3460	1983	100	100	0.316	0.296	0.282	0.295	0.297
13.3	2680	1984	100	100	0.255	0.240	0.230	0.239	0.241
5.8	3550	1983	100	100	1.267	1.173	1.105	1.168	1.178
9.1	3620	1983	100	100	0.565	0.528	0.501	0.526	0.530
10.6	3840	1984	100	100	0.390	0.367	0.349	0.365	0.368
5.6	4840	1983	100	100	0.878	0.812	0.765	0.808	0.816
5.6	3330	1983	100	100	0.164	0.152	0.143	0.151	0.153
6.1	2650	1983	100	100	0.451	0.417	0.392	0.415	0.419
6.1	2650	1983	100	100	0.597	0.552	0.520	0.549	0.554
1.0	1430	1984	100	100	0.173	0.157	0.145	0.156	0.157
2.5	2010	1984	100	100	0.084	0.076	0.071	0.076	0.077
3.3	1460	1984	100	100	0.193	0.177	0.166	0.176	0.178
1.2	1650	1982	100	100	0.035	0.032	0.029	0.032	0.032
1.6	1690	1983	100	100	0.102	0.092	0.086	0.092	0.093
4.1	1410	1982	100	100	0.025	0.023	0.021	0.023	0.023
3.0	1350	1983	100	100	0.193	0.177	0.165	0.176	0.178
0.0	0	1984	100	100	0.056	0.052	0.048	0.051	0.052
8.6	4150	1982	100	100	0.155	0.145	0.137	0.144	0.145
9.4	3810	1982	100	100	0.093	0.087	0.083	0.087	0.088
12.3	4520	1984	100	100	0.707	0.664	0.633	0.661	0.666
6.9	8790	1983	100	100	1.055	0.984	0.932	0.979	0.987
15.8	4510	1983	100	100	0.858	0.815	0.783	0.812	0.817
9.4	4040	1982	100	100	0.367	0.343	0.326	0.342	0.344
16.0	4500	1983	100	100	0.030	0.029	0.028	0.029	0.029
11.7	5400	1984	100	100	0.688	0.648	0.620	0.646	0.650
8.4	4400	1982	100	100	0.084	0.078	0.074	0.078	0.079

Table 14. NOx inventory (highway sources): definition of the field headings.

Field Heading	Definition
HIGHWAY	Highway number (i.e., 1, 2 or 16).
SEG-NO	Segment number.
FROM-LOC	From-location of the highway segment.
TO-LOC	To-location of the highway segment.
LENGTH	Length of the highway segment.
ECOREGION	Ecoregion (See Table 1H) in which the facility is located.
PV-W	Percentage of the total volume of westbound traffic which are passenger vehicles.
RV-W	Percentage of the total volume of westbound traffic which are recreation vehicles.
BUSES-W	Percentage of the total volume of westbound traffic which are buses.
SUT-W	Percentage of the total volume of westbound traffic which are single unit trucks.
TRT-W	Percentage of the total volume of westbound traffic which are tractor-trailer units.
AADT-W	Average annual daily westbound traffic volume.
PV-E	Percentage of the total volume of eastbound traffic which are passenger vehicles.
RV-E	Percentage of the total volume of eastbound traffic which are recreation vehicles.

Continued...

Table 14 (concluded).

Field Heading	Definition
BUSES-E	Percentage of the total volume of eastbound traffic which are buses.
SUT-E	Percentage of the total volume of eastbound traffic which are single unit trucks.
TRT-E	Percentage of the total volume of eastbound traffic which are tractor-trailer units.
AADT-E	Average annual daily eastbound traffic volume.
YEAR	Year for which the traffic volume breakdown data are presented.
CAR-SPD	Maximum speed limit for all motor vehicles except trucks.
TRK-SPD	Maximum speed limit for trucks.
ER-1ST-QRT	Average daily NOx emission rate for the first quarter, t/d.
ER-2ND-QRT	Average daily NOx emission rate for the second quarter, t/d.
ER-3RD-QRT	Average daily NOx emission rate for the third quarter, t/d.
ER-4TH-QRT	Average daily NOx emission rate for the fourth quarter, t/d.
ER-AVERAGE	Annual rate of NOx emission, t/d.

4. INVENTORY OF AIR QUALITY MONITORING STATIONS

The primary purpose of the NOx and SO_2 emission inventories is to provide a comprehensive and easy-to-use listing of emission information that may be used in the prediction of local and regional air quality. Once air quality predictions have been made, it is desirable to have actual air quality data for comparison. For this reason, the inventory of air quality monitoring stations in Alberta has been compiled. Details of this inventory are presented in the following subsections.

In addition, a brief description is provided of the climatological stations, air quality monitoring networks and precipitation quality networks in Alberta, since this is relevant information which may also be of use to users of the developed inventories.

4.1 METHODOLOGY

Only air quality monitoring stations in long-term monitoring programs, which are generally required as a condition of Clean Air Licences, have been inventoried. Those used in short-term or discontinued monitoring programs have not been included.

Any industrial facility that Standards and Approvals Division, Alberta Environment, considers to be a significant source of atmospheric pollutants is required to obtain a Clean Air Act Licence to Operate. As a condition of these licences, the operating companies may be required to conduct specified air quality monitoring in the surrounding area. To identify and delineate these and government sponsored air quality monitoring programs, Pollution Control Division, Alberta Environment, has served as the principal source of information. It is to this government body that monitoring results are reported.

4.2 CHARACTERIZATION OF AIR QUALITY MONITORING STATIONS

The basic data set used to characterize each air quality monitoring program is as follows:

1. Location - The location of each facility about which air quality monitoring is conducted. The location of these has been defined using Alberta's legal land system (see Figures 1 and 2).
2. Name - The recognized name of the facility.
3. Operator - The name of the company or agency that operates the air quality monitoring station.
4. Industry - The industrial sector of which the facility is a part. The industrial classifications are those listed previously in Table 2.
5. Licence Number - Where a Clean Air Act Licence has been issued for operation of the facility, the reference number of that licence.
6. Stacks - The number of vent or exhaust stacks located at the facility that are equipped with continuous stack emission monitors.
7. Stack Surveys - The number of times that the stacks must be surveyed each year*.

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* Stack surveys serve as an accuracy check of the continuous stack emission monitors.

8. Monitoring - The number of months each year that continuous air quality monitoring is conducted about the pollution source.
9. Licensed SO_2 Emission Rate - Where appropriate, the maximum allowable SO_2 emission rate (t/d) specified in the facility's Clean Air Act Licence.
10. Reporting - The number of monthly, quarterly, and annual emission reports that the operator must submit to Pollution Control Division, Alberta Environment.
11. Monitoring Equipment - The number of locations, about and near the facility, at which the following types of monitoring devices or measurements are used:
    - total sulphation cylinder
    - fluoride cylinder
    - dustfall canister
    - high volume dust sampler
    - sequential fluoride sampler
    - vegetation
    - soil pH
    - heavy metal analysis
    - gas analysis
    - continuous NOx monitor
    - continuous SO_2 monitor
    - continuous H_2S monitor
    - continuous total hydrocarbon (THC) monitor
    - wind anemometer and weather vane

4.3 SAMPLE OF THE INVENTORY

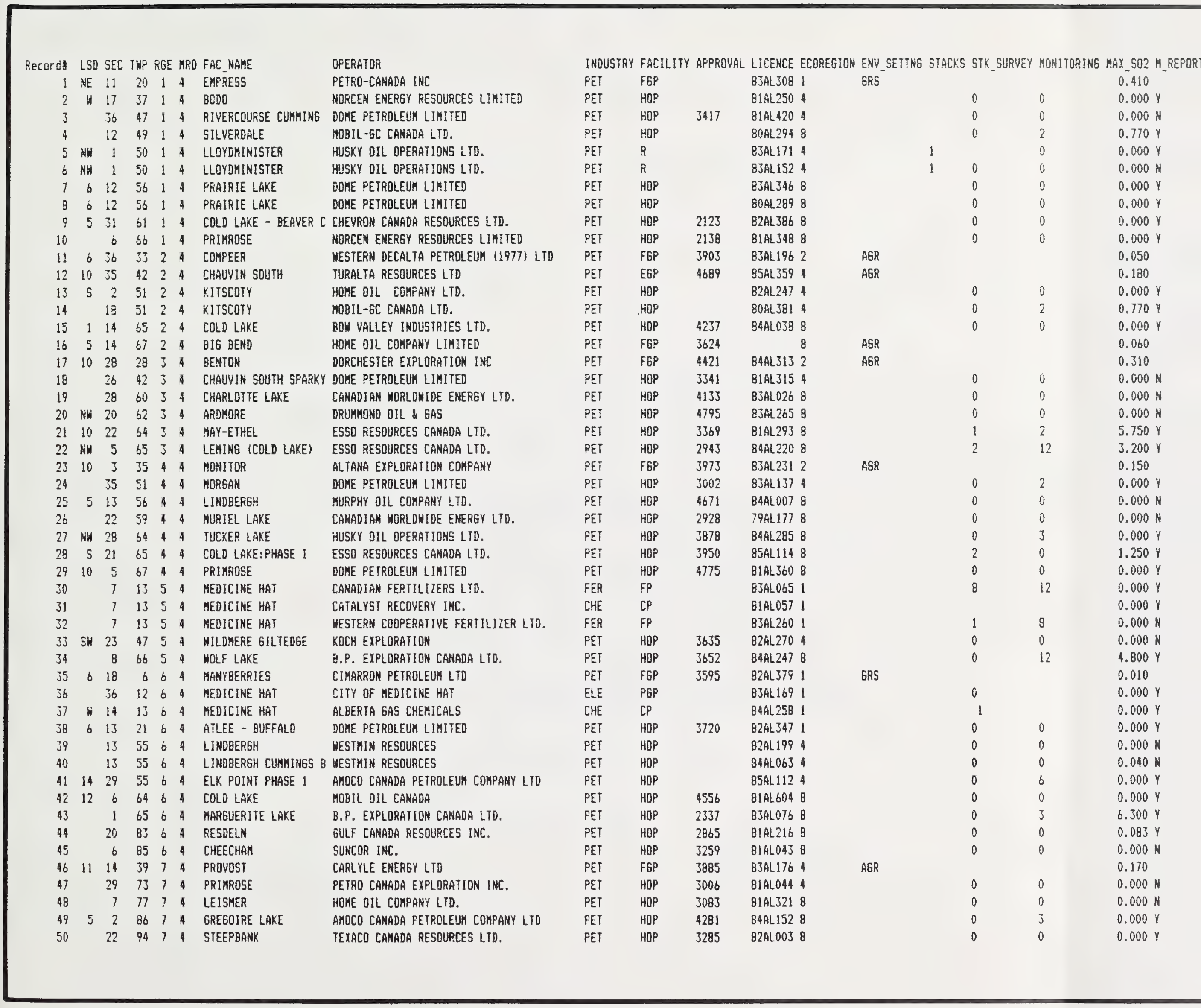
A sample of the inventory of air quality monitoring stations is presented in Figure 7. The field headings that appear in Figure 7 are defined in Table 15.

4.4 ADDITIONAL INFORMATION

4.4.1 Climatological Stations

In Alberta, the vast majority of the climatological data are collected by Alberta Government agencies. In all, 13 agencies are currently involved in such data collection. A good overview of the climatological data collection activities of these agencies is provided by Hansen and Jones (1982). Climatological data are also collected by the operators of most industrial facilities and by the academic community.

The majority of the data collected by Alberta Government Agencies are reported to Environment Canada. A catalogue is published by Environment Canada (1981), which identifies the climatological stations reporting to it, and the types of data that these collect.



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Record# LSD SEC TWP RGE MRD FAC_NAME             OPERATOR                                  INDUSTRY FACILITY APPROVAL LICENCE ECOREGION ENV_SETTNG STACKS STK_SURVEY MONITORING MAX_SO2 M_REPORT
     1  NE  11  20   1   4 EMPRESS              PETRO-CANADA INC                          PET      FGP               83AL308 1         GRS                                       0.410
     2   W  17  37   1   4 BODO                 NORCEN ENERGY RESOURCES LIMITED           PET      HOP               81AL250 4                            0          0           0.000 Y
     3      36  47   1   4 RIVERCOURSE CUMMING  DOME PETROLEUM LIMITED                    PET      HOP      3417     81AL420 4                            0          0           0.000 N
     4      12  49   1   4 SILVERDALE           MOBIL-GC CANADA LTD.                      PET      HOP               80AL294 8                            0          2           0.770 Y
     5  NW   1  50   1   4 LLOYDMINISTER        HUSKY OIL OPERATIONS LTD.                 PET      R                 83AL171 4                     1                 0           0.000 Y
     6  NW   1  50   1   4 LLOYDMINISTER        HUSKY OIL OPERATIONS LTD.                 PET      R                 83AL152 4                     1      0          0           0.000 N
     7   6  12  56   1   4 PRAIRIE LAKE         DOME PETROLEUM LIMITED                    PET      HOP               83AL346 8                            0          0           0.000 Y
     8   6  12  56   1   4 PRAIRIE LAKE         DOME PETROLEUM LIMITED                    PET      HOP               80AL289 8                            0          0           0.000 Y
     9   5  31  61   1   4 COLD LAKE - BEAVER C CHEVRON CANADA RESOURCES LTD.             PET      HOP      2123     82AL386 8                            0          0           0.000 Y
    10       6  66   1   4 PRIMROSE             NORCEN ENERGY RESOURCES LIMITED           PET      HOP      2138     81AL348 8                            0          0           0.000 Y
    11   6  36  33   2   4 COMPEER              WESTERN DECALTA PETROLEUM (1977) LTD      PET      FGP      3903     83AL196 2         AGR                                       0.050
    12  10  35  42   2   4 CHAUVIN SOUTH        TURALTA RESOURCES LTD                     PET      EGP      4689     85AL359 4         AGR                                       0.180
    13   S   2  51   2   4 KITSCOTY             HOME OIL  COMPANY LTD.                    PET      HOP               82AL247 4                            0          0           0.000 Y
    14      18  51   2   4 KITSCOTY             MOBIL-GC CANADA LTD.                      PET      HOP               80AL381 4                            0          2           0.770 Y
    15   1  14  65   2   4 COLD LAKE            BOW VALLEY INDUSTRIES LTD.                PET      HOP      4237     84AL038 8                            0          0           0.000 Y
    16   5  14  67   2   4 BIG BEND             HOME OIL COMPANY LIMITED                  PET      FGP      3624             8         AGR                                       0.060
    17  10  28  28   3   4 BENTON               DORCHESTER EXPLORATION INC                PET      FGP      4421     84AL313 2         AGR                                       0.310
    18      26  42   3   4 CHAUVIN SOUTH SPARKY DOME PETROLEUM LIMITED                    PET      HOP      3341     81AL315 4                            0          0           0.000 N
    19      28  60   3   4 CHARLOTTE LAKE       CANADIAN WORLDWIDE ENERGY LTD.            PET      HOP      4133     83AL026 8                            0          0           0.000 N
    20  NW  20  62   3   4 ARDMORE              DRUMMOND OIL & GAS                        PET      HOP      4795     83AL265 8                            0          0           0.000 N
    21  10  22  64   3   4 MAY-ETHEL            ESSO RESOURCES CANADA LTD.                PET      HOP      3369     81AL293 8                            1          2           5.750 Y
    22  NW   5  65   3   4 LEMING (COLD LAKE)   ESSO RESOURCES CANADA LTD.                PET      HOP      2943     84AL220 8                            2          12          3.200 Y
    23  10   3  35   4   4 MONITOR              ALTANA EXPLORATION COMPANY                PET      FGP      3973     83AL231 2         AGR                                       0.150
    24      35  51   4   4 MORGAN               DOME PETROLEUM LIMITED                    PET      HOP      3002     83AL137 4                            0          2           0.000 Y
    25   5  13  56   4   4 LINDBERGH            MURPHY OIL COMPANY LTD.                   PET      HOP      4671     84AL007 8                            0          0           0.000 N
    26      22  59   4   4 MURIEL LAKE          CANADIAN WORLDWIDE ENERGY LTD.            PET      HOP      2928     79AL177 8                            0          0           0.000 N
    27  NW  28  64   4   4 TUCKER LAKE          HUSKY OIL OPERATIONS LTD.                 PET      HOP      3878     84AL285 8                            0          3           0.000 Y
    28   S  21  65   4   4 COLD LAKE:PHASE I    ESSO RESOURCES CANADA LTD.                PET      HOP      3950     85AL114 8                            2          0           1.250 Y
    29  10   5  67   4   4 PRIMROSE             DOME PETROLEUM LIMITED                    PET      HOP      4775     81AL360 8                            0          0           0.000 Y
    30       7  13   5   4 MEDICINE HAT         CANADIAN FERTILIZERS LTD.                 FER      FP                83AL065 1                            8          12          0.000 Y
    31       7  13   5   4 MEDICINE HAT         CATALYST RECOVERY INC.                    CHE      CP                81AL057 1                                                   0.000 Y
    32       7  13   5   4 MEDICINE HAT         WESTERN COOPERATIVE FERTILIZER LTD.       FER      FP                83AL260 1                            1          8           0.000 N
    33  SW  23  47   5   4 WILDMERE GILTEDGE    KOCH EXPLORATION                          PET      HOP      3635     82AL270 4                            0          0           0.000 N
    34       8  66   5   4 WOLF LAKE            B.P. EXPLORATION CANADA LTD.              PET      HOP      3652     84AL247 8                            0          12          4.800 Y
    35   6  18   6   6   4 MANYBERRIES          CIMARRON PETROLEUM LTD                    PET      FGP      3595     82AL379 1         GRS                                       0.010
    36      36  12   6   4 MEDICINE HAT         CITY OF MEDICINE HAT                      ELE      PGP               83AL169 1                            0                      0.000 Y
    37   W  14  13   6   4 MEDICINE HAT         ALBERTA GAS CHEMICALS                     CHE      CP                84AL258 1                             1                     0.000 Y
    38   6  13  21   6   4 ATLEE - BUFFALO      DOME PETROLEUM LIMITED                    PET      HOP      3720     82AL347 1                            0          0           0.000 Y
    39      13  55   6   4 LINDBERGH            WESTMIN RESOURCES                         PET      HOP               82AL199 4                            0          0           0.000 N
    40      13  55   6   4 LINDBERGH CUMMINGS B WESTMIN RESOURCES                         PET      HOP               84AL063 4                            0          0           0.040 N
    41  14  29  55   6   4 ELK POINT PHASE 1    AMOCO CANADA PETROLEUM COMPANY LTD        PET      HOP               85AL112 4                            0          6           0.000 Y
    42  12   6  64   6   4 COLD LAKE            MOBIL OIL CANADA                          PET      HOP      4556     81AL604 8                            0          0           0.000 Y
    43       1  65   6   4 MARGUERITE LAKE      B.P. EXPLORATION CANADA LTD.              PET      HOP      2337     83AL076 8                            0          3           6.300 Y
    44      20  83   6   4 RESDELN              GULF CANADA RESOURCES INC.                PET      HOP      2865     81AL216 8                            0          0           0.083 Y
    45       6  85   6   4 CHEECHAM             SUNCOR INC.                               PET      HOP      3259     81AL043 8                            0          0           0.000 N
    46  11  14  39   7   4 PROVOST              CARLYLE ENERGY LTD                        PET      FGP      3885     83AL176 4         AGR                                       0.170
    47      29  73   7   4 PRIMROSE             PETRO CANADA EXPLORATION INC.             PET      HOP      3006     81AL044 4                            0          0           0.000 N
    48       7  77   7   4 LEISMER              HOME OIL COMPANY LTD.                     PET      HOP      3083     81AL321 8                            0          0           0.000 N
    49   5   2  86   7   4 GREGOIRE LAKE        AMOCO CANADA PETROLEUM COMPANY LTD        PET      HOP      4281     84AL152 8                            0          3           0.000 Y
    50      22  94   7   4 STEEPBANK            TEXACO CANADA RESOURCES LTD.              PET      HOP      3285     82AL003 8                            0          0           0.000 Y
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Figure 7.   A sample of the inventory of air quality monitoring stations.

]RING	MAX_SO2	M_REPORT	Q_REPORT	A_REPORT	SO2_CYL	NOX_CYL	F_CYL	DUSTFALL	HIGHVOL	F_SEQENTAL	VEGETATION	SOIL_PH	HEAVYMETAL	GAS_ANALYS	NOX	SO2	H2S	THC	WIND
	0.410				Y														
	0.000	Y	N	N	0									1		0	0		0
	0.000	N	N	N	0									1		0	0		0
	0.770	Y	N	N	1									2		1	1		1
	0.000	Y	N	Y	4			0											
	0.000	N	N	N	0			0											
	0.000	Y	N	N	2									1		0	0		0
	0.000	Y	N	N	0									1		0	0		0
	0.000	Y	N	Y	4									1		0	0		0
	0.000	Y	N	Y	4									1		0	0		0
	0.050				Y														
	0.180				Y											Y	Y		Y
	0.000	Y	N	N	0									1		0	0		0
	0.770	Y	N	N	1									2		1	1		1
	0.000	Y	N	N	0									0		0	0		0
	0.060				Y														
	0.310				Y														
	0.000	N	N	N	0									1		0	0		0
	0.000	N	Y	N	0									1		0	0		0
	0.000	N	N	N	0									1		0	0		0
	5.750	Y	N	N	4									0		1	1		1
	3.200	Y	N	Y	12									1		1	1		1
	0.150				Y														
	0.000	Y	N	N	6									1		1	1		1
	0.000	N	N	N	0									1		0	0		0
	0.000	N	N	N	0									1		0	0		0
	0.000	Y	N	N	1									1		1	1		1
	1.250	Y	N	Y	12									0		0	0		0
	0.000	Y	N	N	4									1		0	0		0
	0.000	Y	N	Y	0		8	0	0	0	0								
	0.000	Y		N	0		0												0
	0.000	N	N	Y	8		0		3	10	10								
	0.000	N	Y	N	0									1		0	0		0
	4.800	Y	N	N	8									1		1	1		1
	0.010				Y														
	0.000	Y		N	0	0	0	0					N		1	1			
	0.000	Y		N	0		0												0
	0.000	Y	N	N	0									1		0	0		0
	0.000	N	N	N	0									1		0	0		0
	0.040	N	Y	N	0									1		0	0		0
	0.000	Y	N	Y	4									1		1	1		1
	0.000	Y	N	N	0									1		0	0		0
	6.300	Y	N	N	8									1		1	1		1
	0.083	Y	N	Y	0									0		0	0		0
	0.000	N	N	N	0									1		0	0		0
	0.170				Y														
	0.000	N	N	N	0									2		0	0		0
	0.000	N	Y	N	0									1		0	0		0
	0.000	Y	N	N	4									2		1	1		1
	0.000	Y	N	N	0									1		0	0		0

Table 15. Inventory of air quality monitoring stations: definition of the field headings.

Field Headings	Definition
LSD	Legal subdivision in which the facility is located.
SEC	Section in which the facility is located.
TWP	Township in which the facility is located.
RGE	Range in which the facility is located.
MRD	Closest meridian located east of the facility.
FAC-NAME	Name of the facility about which the air quality monitoring is conducted.
OPERATOR	Name of the company which operates the facility.
INDUSTRY	Industry sector with which the facility is associated (see Tables 1A and 3A).
FACILITY	Type of facility (see Tables 1A and 3A).
APPROVAL	Approval number of facilities which have been approved by ERCB.
LICENCE	Licence number of facilities which have been licenced to operate under the Clean Air Act.
ECOREGION	Ecoregion (see Table 1H), in which the facility is located.
ENV-SETTING	Environmental setting (see Table 1G).

Continued...

Table 15 (continued).

Field Headings	Definition
STACKS	Number of major vent or exhaust stacks located at the facility.
STK-SURVEY	Number of stack surveys which are required to be conducted annually.
MONITORING	Number of months each year during which ambient monitoring is required to be conducted.
MAX-SO_2	Maximum licenced daily rate of SO_2 emission, t/d.
M-REPORT	Are reports submitted to Pollution Control Division, Alberta Environment, on a monthly basis, (yes or no).
Q-REPORT	Are reports submitted to Pollution Control Division, Alberta Environment, on a quarterly basis, (yes or no).
A-REPORT	Are reports submitted to Pollution Control Division, Alberta Environment, on an annual basis, (yes or no).
SO_2-CYL	Number of total sulphation cylinders, (yes if sulphation cylinders are known to be used but the actual number in use is unavailable).
NOx-CYL	Number of NOx cylinders.
F-CYL	Number of fluoride cylinders.
DUSTFALL	Number of dustfall canisters.
HIGHVOL	Number of high volume dust samplers.
R-SEQUENTIAL	Number of sequential fluoride samplers.

Continued...

Table 15 (concluded).

Field Headings	Definition
VEGETATION	Number of vegetation samples collected annually.
SOIL-pH	Number of samples collected annually as part of the soil pH monitoring program.
HEAVY METAL	Number of heavy metal analyses conducted annually.
GAS-ANALYSES	Number of gas analyses conducted annually.
NOx	Number of continuous NOx monitors.
SO_2	Number of continuous SO_2 monitors.
H_2S	Number of continuous H_2S monitors.
THC	Number of continuous total hydrocarbon (THC) monitors.
WIND	Number of wind anemometer and weather vane devices.

Copies may be obtained from:

Climatological Services Division
Atmospheric Environment Service
4905 Dufferin Street
Downsview, Ontario. M3H 5T4

Additional information regarding the stations and observing programs listed in this catalogue may be obtained from:

Regional Director
Atmospheric Environment Service
Argyll Centre
6325 - 103 Street
Edmonton, Alberta. T6H 5H6

Although a large volume of climatological data is collected in Alberta, it is important to realize that, in general, such information is not conveniently available for use by others. As noted by Hansen and Jones (1982), the thirteen agencies involved in the collection of climatological data do not have well developed data management systems. In addition, programs for communicating information on collection programs and making data easily accessible do not exist at the present time.

4.4.2 Air Quality Monitoring Networks

In Alberta there are three air quality monitoring networks; one is operated by the Strathcona Industrial Association, and the other two by Alberta Environment.

The Strathcona Industrial Association is a group of nine companies that operate facilities in the industrial area of east Edmonton and the County of Strathcona. The member companies are:

- Alcan Smelters and Chemicals Ltd.
- Celanese Canada Inc.
- C-I-L Inc.
- Fiberglass Canada Ltd.
- Gulf Canada Products Company
- Esso Petroleum Canada
- Interprovincial Pipe Line Limited
- STELCO Inc.
- Turbo Refineries Ltd.

In 1976 the Strathcona Industrial Association began integrating the individual monitoring programs of the member companies to form a sophisticated air quality monitoring network for the area. This network was fully operational by 1980 and in 1982 was modified to allow the government instantaneous access to both current and historical data. The network, itself, consists of six computer-linked monitoring stations strategically located around the industrial area. Four of these are located in the residential areas of Beverly, Gold Bar, Clareview, and Sherwood Park. Each station monitors for:

- Hydrogen sulphide (H_2S),
- Oxides of nitrogen (NOx),
- Total suspended particulate matter (dust particles),
- Total hydrocarbons (THC),
- Sulphur dioxide (SO_2), and
- Wind speed and direction.

Further information regarding the Strathcona Industrial Association and its air quality monitoring network may be obtained from:

Chairman, Technical Committee - (403) 464-8643
Strathcona Industrial Association
c/o Petro-Canada Products
Box 97
Edmonton, Alberta, T5J 2G9

The Air Quality Control Branch of the Pollution Control Division of Alberta Environment has operated continuous, and passive air quality monitoring networks in both Calgary and Edmonton since 1974. The continuous ambient air monitoring networks collect data on nitrogen oxides, nitrogen dioxide, nitrogen oxide, ozone, sulphur dioxide, and total hydrocarbons. The passive networks measure total dustfall and total sulphation.

For both Calgary and Edmonton, the continuous monitoring network consists of three permanently located stations and one mobile station. A mobile station is also being used in Fort McMurray. The permanent stations for Calgary and Edmonton are strategically located in downtown, residential, and industrial areas.

The exact location of each of these is provided in Table 16 along with heights of the station and sampling point.

A summary of the passive air monitoring networks in Calgary and Edmonton is provided in Table 17.

In addition, Alberta Environment operates passive and intermittent air monitoring stations in a number of urban centres and around a number of rural industrial operations throughout the province (the intermittent stations sample suspended particulate matter). A summary of this is provided in Table 18.

Further information regarding the two metropolitan air quality monitor networks may be obtained from:

Alberta Environment
Pollution Control Division
Air Quality Control Branch
9820 - 106 Street
Edmonton, Alberta. T5K 2J6

Table 16. Continuous air quality monitoring stations in Calgary and Edmonton.

City	Area	Location	Height of Sample Inlet Above Ground (m)
Calgary	Downtown	4 St. & 6 Ave. S.W.	6
Calgary	Residential	39 St. & 29 Ave. N.W.	4
Calgary	Industrial	18A St. & 45 Ave. S.E.	4
Edmonton	Downtown	104 St. & 103 Ave.	8.5
Edmonton	Residential	127 St. & 133 Ave.	3.5
Edmonton	Industrial	17 St. & 105 Ave.	5.0

Table 17. Passive air quality monitoring stations in Calgary and Edmonton.

Monitoring Parameter	Number of Stations	
	Calgary	Edmonton
Total Sulphation	38	29
Total Dustfall		
- Residential and Recreational Areas	26	20
- Commercial and Industrial Areas	12	9

Table 18. Passive and intermittent air quality monitoring stations at small urban centres and industrial operations in Alberta.

Monitoring Parameter	Number of Stations	
	Small Urban Centres	Rural Industrial Operations
Passive Monitoring		
Total Sulphation	33	159
H_2S	29	154
Total Dustfall	19	32
Intermittent Monitoring		
Fluoride Samplers	9	4
High Volume Samplers	1	0

4.4.3 Precipitation Quality Monitoring Networks

In Alberta, there are three precipitation quality monitoring networks. Two are operated by the Air Quality Control Branch of the Pollution Control Division of Alberta Environment: the Precipitation Quality Monitoring Network (PQMN) and the Air Precipitation and Air Chemistry Program (APACP). The other is part of a nation-wide network called the Canadian Air and Precipitation Monitoring Network (CAPMoN) and is operated by the Atmospheric Environment Service of Environment Canada. The purpose of these networks is to monitor changes and trends in the quality of precipitation and to provide a data base that may be used to determine the effects of wet deposition of chemical species on the environment. The PQMN collects data on a monthly basis and the APACP and CAPMoN collect data on a daily basis.

The information recorded at each station consists of:

- sample period - the number of days the collector was exposed;
- catch of collector - the amount of precipitation collected by the collector (mL);
- catch of standard - the amount of precipitation collected by the standard rain gauge (mm);
- pH - the negative logarithm of the hydrogen ion concentration;
- conductance - measure of change in inorganic content (mS/cm);
- sulphate ion concentration, SO_4^{2-} (mg/L);
- nitrate ion concentration, NO_3^- (mg/L);
- ammonium ion concentration, NH_4^+ (mg/L);
- chloride ion concentration, Cl^- (mg/L);
- orthophosphate ion concentration, (mg/L);
- sodium ion concentration, Na^+ (mg/L);
- potassium ion concentration, K^+ (mg/L);
- calcium ion concentration, Ca^{2+} (mg/L);
- magnesium ion concentration, Mg^{2+} (mg/L)

The PQMN consists of ten stations located throughout the province. Six of these were established in 1978 at Beaverlodge, Calgary, Edmonton, Red Deer, Suffield, and Whitecourt. Four more were added to the network in 1985 at Fort McMurray, Cold Lake, High Level, and Kananaskis.

The APACP, established in 1987, consists of a single station located at High Prairie.

The Alberta portion of CAPMoN consists of one station located at Esther. This station has been in operation since 1986. Prior to 1986, Environment Canada operated five stations in Alberta as part of the now discontinued Canadian Network for Sampling Precipitation (CANSAP). These stations were located at:

- Coronation,
- Edson,
- Fort McMurray,
- Lethbridge, and
- Rocky Mountain House.

Data were collected on a monthly basis at each of these stations.

Further details concerning both the Alberta Environment stations and the CAPMoN stations may be obtained by contacting:

Alberta Environment
Air Quality Control Branch
6th Floor, Oxbridge Place
9820 - 106 Street
Edmonton, Alberta, T5K 2J6

Attention: Section Head
Technical Support

5. COMPUTERIZATION OF THE INVENTORIES

5.1 THE DATA MANAGEMENT SYSTEM

The most effective means of handling large amounts of information is through the use of computers. To enable computers to efficiently organize, modify, sort, retrieve, and report information, data management systems (DMS) are used.

In selecting a suitable DMS, an attempt was made to avoid using those that must be operated on a mainframe computer. By utilizing microcomputers, cost and accessibility problems typically associated with mainframes are avoided.

To manage the inventories developed here, a DMS known as dBASE III was selected. dBASE III is currently one of the more powerful and popular data management systems available for microcomputer applications. It is designed for use by 16-bit microcomputers and runs on the IBM PC, COMPAQ, Corona and compatibles.

The primary reasons for the selection of dBASE III have been:

1. Its ability to work with extremely large data files. The dBASE III data file may consist of over one billion records, and each record may consist of up to 128 fields or be up to 4,000 characters long. In addition, dBASE III also allows the use of special MEMO data fields, which increases the effective maximum allowable record length to 500,000 characters.

   In comparison, many DMS's, such as the popular LOTUS 1-2-3 and SYMPHONY are RAM-based (RAM is the acronym for random access memory) systems so that the maximum size of a data file is determined by the amount of active memory available. For example, if SYMPHONY, which requires approximately 300 k of RAM, is loaded onto a moderately-sized system of 640 k RAM, the largest data file that may be created is essentially 340 k (equivalent to approximately 64 pages of information). However, dBASE III, like many of the more powerful DMS's, transfers blocks of data back and forth between allocated active memory and the mass storage memory. In this way, the maximum data file size is essentially determined by the amount of mass storage available.

2. Its popularity and thus good accessibility.

3. Its ability to exchange data with other systems using either a System Data Format (SDF) or a Delimited Format.

4. The ability to sort data using multi-field criteria.

Additional features of dBASE III are:

1. If a number of different criteria are frequently used to sort the data file each time a change in the sorting criterion or format occurs, the various formats may be recorded through the use of index files.
2. dBASE III is a relational DMS; it may store data in more than one file and retrieve, or update, several files simultaneously. Up to 10 data files may be in use at the same time.
3. dBASE III may be operated interactively and, for the infrequent user, special user-friendly ASSIST and HELP modes are available.
4. Application programs may be created with features such as procedures, data processing, and parameter passing.
5. dBASE III also has built-in interactive calculator capabilities and report-preparing features.

5.2 ALBERTA ATMOSPHERIC EMISSION SOURCE INVENTORY (AAESI): A DEVELOPED APPLICATION PROGRAM

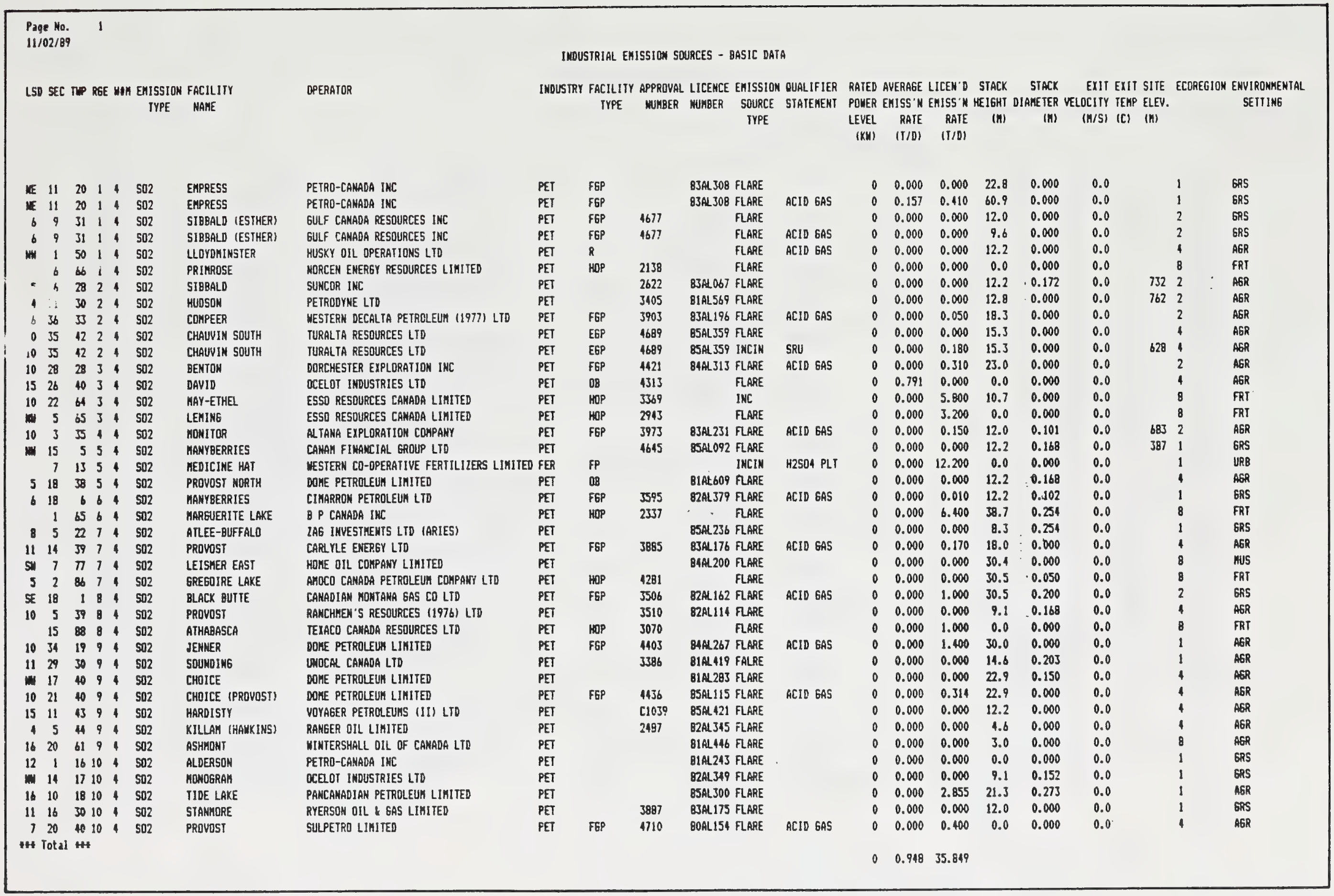
As discussed in the previous section, dBASE III is a powerful and flexible data management system. However, in achieving this, it makes use of a large number of commands which, unfortunately, can make operation of the system appear quite complex. To utilize its capabilities fully, the user must be prepared to go through the dBASE III user's manual and spend a number of hours working with the system. However, for basic data management tasks, there are only a few commands with which the user needs to be familiar. These can be learned by going through the first few chapters of the dBASE III user's manual, and within a few hours the user can be sufficiently competent to work with the developed data files. To simplify use of the inventories further, a special application program, AAESI, has been developed (AAESI is the acronym for Alberta Atmospheric Emission Source Inventory). Once activated, this program enables the user to work with the inventories by simply responding to menu selections that require a minimal knowledge of dBASE III.

Basically, AAESI is intended to serve two purposes: first, to enable novices to work with the compiled inventories after only a few minutes of instruction; and second, to relieve the user of some of the more tedious tasks that might typically be encountered in working with the inventories.

The basic tasks programmed into AAESI are the ability to:

- enter new data,
- edit existing data,
- sort data within the files,
- calculate probable emission rates and emission rate precisions,
- retrieve data according to a number of different criteria,
- output the retrieved data either to the printer or to mass storage files,
- prepare tabular summaries of the retrieved data,
- make a backup copy of AAESI and the data base files; and
- exit AAESI.

Samples of the tabular summaries that may be prepared using AAESI's reporting features are presented in Figures 8A through 8H.



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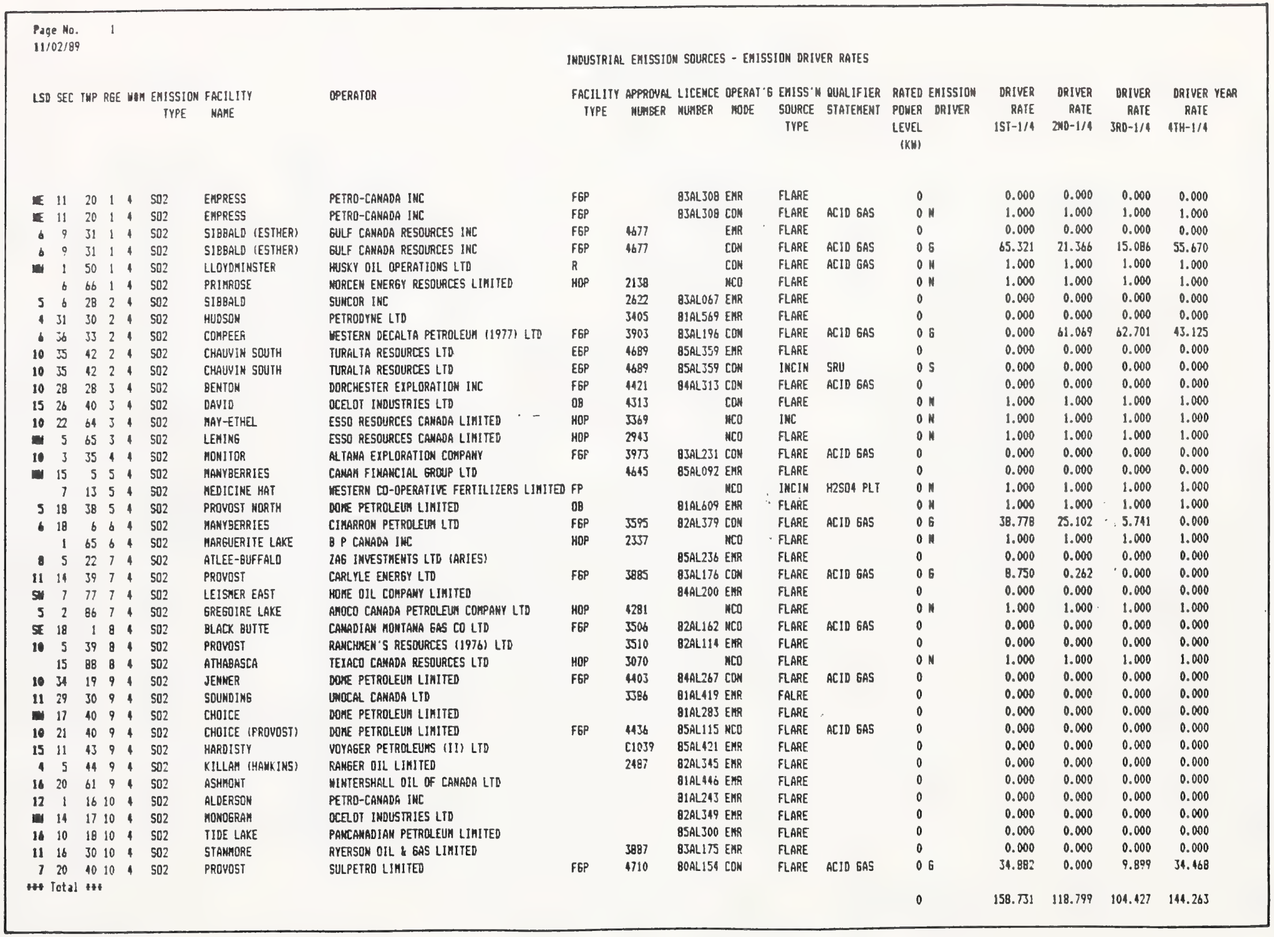
                                                        INDUSTRIAL EMISSION SOURCES - BASIC DATA

LSD SEC TWP RGE W#M EMISSION FACILITY          OPERATOR                               INDUSTRY FACILITY APPROVAL LICENCE EMISSION QUALIFIER RATED AVERAGE LICEN'D STACK    STACK     EXIT EXIT SITE  ECOREGION ENVIRONMENTAL
                    TYPE     NAME                                                              TYPE     NUMBER  NUMBER   SOURCE  STATEMENT  POWER EMISS'N EMISS'N HEIGHT DIAMETER VELOCITY TEMP ELEV.                SETTING
                                                                                                                          TYPE              LEVEL   RATE    RATE   (M)      (M)     (M/S) (C)  (M)
                                                                                                                                             (KW)   (T/D)   (T/D)

NE  11  20  1  4   SO2     EMPRESS             PETRO-CANADA INC                        PET      FGP               83AL308 FLARE                 0   0.000   0.000  22.8    0.000     0.0             1          GRS
NE  11  20  1  4   SO2     EMPRESS             PETRO-CANADA INC                        PET      FGP               83AL308 FLARE    ACID GAS     0   0.157   0.410  60.9    0.000     0.0             1          GRS
 6   9  31  1  4   SO2     SIBBALD (ESTHER)    GULF CANADA RESOURCES INC               PET      FGP      4677             FLARE                 0   0.000   0.000  12.0    0.000     0.0             2          GRS
 6   9  31  1  4   SO2     SIBBALD (ESTHER)    GULF CANADA RESOURCES INC               PET      FGP      4677             FLARE    ACID GAS     0   0.000   0.000   9.6    0.000     0.0             2          GRS
NW   1  50  1  4   SO2     LLOYDMINSTER        HUSKY OIL OPERATIONS LTD                PET      R                         FLARE    ACID GAS     0   0.000   0.000  12.2    0.000     0.0             4          AGR
     6  66  1  4   SO2     PRIMROSE            NORCEN ENERGY RESOURCES LIMITED         PET      HOP      2138             FLARE                 0   0.000   0.000   0.0    0.000     0.0             8          FRT
[illegible] 6  28  2  4   SO2     SIBBALD             SUNCOR INC                              PET               2622    83AL067 FLARE                 0   0.000   0.000  12.2    0.172     0.0        732  2          AGR
 4 [illegible]  30  2  4   SO2     HUDSON              PETRODYNE LTD                           PET               3405    81AL569 FLARE                 0   0.000   0.000  12.8    0.000     0.0        762  2          AGR
 6  36  33  2  4   SO2     COMPEER             WESTERN DECALTA PETROLEUM (1977) LTD    PET      FGP      3903    83AL196 FLARE    ACID GAS     0   0.000   0.050  18.3    0.000     0.0             2          AGR
 0  35  42  2  4   SO2     CHAUVIN SOUTH       TURALTA RESOURCES LTD                   PET      EGP      4689    85AL359 FLARE                 0   0.000   0.000  15.3    0.000     0.0             4          AGR
10  35  42  2  4   SO2     CHAUVIN SOUTH       TURALTA RESOURCES LTD                   PET      EGP      4689    85AL359 INCIN    SRU          0   0.000   0.180  15.3    0.000     0.0        628  4          AGR
10  28  28  3  4   SO2     BENTON              DORCHESTER EXPLORATION INC              PET      FGP      4421    84AL313 FLARE    ACID GAS     0   0.000   0.310  23.0    0.000     0.0             2          AGR
15  26  40  3  4   SO2     DAVID               OCELOT INDUSTRIES LTD                   PET      OB       4313             FLARE                 0   0.791   0.000   0.0    0.000     0.0             4          AGR
10  22  64  3  4   SO2     MAY-ETHEL           ESSO RESOURCES CANADA LIMITED           PET      HOP      3369             INC                   0   0.000   5.800  10.7    0.000     0.0             8          FRT
NW   5  65  3  4   SO2     LEMING              ESSO RESOURCES CANADA LIMITED           PET      HOP      2943             FLARE                 0   0.000   3.200   0.0    0.000     0.0             8          FRT
10   3  35  4  4   SO2     MONITOR             ALTANA EXPLORATION COMPANY              PET      FGP      3973    83AL231 FLARE    ACID GAS     0   0.000   0.150  12.0    0.101     0.0        683  2          AGR
NW  15   5  5  4   SO2     MANYBERRIES         CANAM FINANCIAL GROUP LTD               PET               4645    85AL092 FLARE                 0   0.000   0.000  12.2    0.168     0.0        387  1          GRS
     7  13  5  4   SO2     MEDICINE HAT        WESTERN CO-OPERATIVE FERTILIZERS LIMITED FER     FP                        INCIN    H2SO4 PLT    0   0.000  12.200   0.0    0.000     0.0             1          URB
 5  18  38  5  4   SO2     PROVOST NORTH       DOME PETROLEUM LIMITED                  PET      OB                81AL609 FLARE                 0   0.000   0.000  12.2    0.168     0.0             4          AGR
 6  18   6  6  4   SO2     MANYBERRIES         CIMARRON PETROLEUM LTD                  PET      FGP      3595    82AL379 FLARE    ACID GAS     0   0.000   0.010  12.2    0.102     0.0             1          GRS
     1  65  6  4   SO2     MARGUERITE LAKE     B P CANADA INC                          PET      HOP      2337             FLARE                 0   0.000   6.400  38.7    0.254     0.0             8          FRT
 8   5  22  7  4   SO2     ATLEE-BUFFALO       ZAG INVESTMENTS LTD (ARIES)             PET                        85AL236 FLARE                 0   0.000   0.000   8.3    0.254     0.0             1          GRS
11  14  39  7  4   SO2     PROVOST             CARLYLE ENERGY LTD                      PET      FGP      3885    83AL176 FLARE    ACID GAS     0   0.000   0.170  18.0    0.000     0.0             4          AGR
SW   7  77  7  4   SO2     LEISMER EAST        HOME OIL COMPANY LIMITED                PET                        84AL200 FLARE                 0   0.000   0.000  30.4    0.000     0.0             8          MUS
 5   2  86  7  4   SO2     GREGOIRE LAKE       AMOCO CANADA PETROLEUM COMPANY LTD      PET      HOP      4281             FLARE                 0   0.000   0.000  30.5    0.050     0.0             8          FRT
SE  18   1  8  4   SO2     BLACK BUTTE         CANADIAN MONTANA GAS CO LTD             PET      FGP      3506    82AL162 FLARE    ACID GAS     0   0.000   1.000  30.5    0.200     0.0             2          GRS
10   5  39  8  4   SO2     PROVOST             RANCHMEN'S RESOURCES (1976) LTD         PET               3510    82AL114 FLARE                 0   0.000   0.000   9.1    0.168     0.0             4          AGR
    15  88  8  4   SO2     ATHABASCA           TEXACO CANADA RESOURCES LTD             PET      HOP      3070             FLARE                 0   0.000   1.000   0.0    0.000     0.0             8          FRT
10  34  19  9  4   SO2     JENNER              DOME PETROLEUM LIMITED                  PET      FGP      4403    84AL267 FLARE    ACID GAS     0   0.000   1.400  30.0    0.000     0.0             1          AGR
11  29  30  9  4   SO2     SOUNDING            UNOCAL CANADA LTD                       PET               3386    81AL419 FALRE                 0   0.000   0.000  14.6    0.203     0.0             1          AGR
NW  17  40  9  4   SO2     CHOICE              DOME PETROLEUM LIMITED                  PET                        81AL283 FLARE                 0   0.000   0.000  22.9    0.150     0.0             4          AGR
10  21  40  9  4   SO2     CHOICE (PROVOST)    DOME PETROLEUM LIMITED                  PET      FGP      4436    85AL115 FLARE    ACID GAS     0   0.000   0.314  22.9    0.000     0.0             4          AGR
15  11  43  9  4   SO2     HARDISTY            VOYAGER PETROLEUMS (II) LTD             PET               C1039   85AL421 FLARE                 0   0.000   0.000  12.2    0.000     0.0             4          AGR
 4   5  44  9  4   SO2     KILLAM (HAWKINS)    RANGER OIL LIMITED                      PET               2497    82AL345 FLARE                 0   0.000   0.000   4.6    0.000     0.0             4          AGR
16  20  61  9  4   SO2     ASHMONT             WINTERSHALL OIL OF CANADA LTD           PET                        81AL446 FLARE                 0   0.000   0.000   3.0    0.000     0.0             8          AGR
12   1  16 10  4   SO2     ALDERSON            PETRO-CANADA INC                        PET                        81AL243 FLARE                 0   0.000   0.000   0.0    0.000     0.0             1          GRS
NW  14  17 10  4   SO2     MONOGRAM            OCELOT INDUSTRIES LTD                   PET                        82AL349 FLARE                 0   0.000   0.000   9.1    0.152     0.0             1          GRS
16  10  18 10  4   SO2     TIDE LAKE           PANCANADIAN PETROLEUM LIMITED           PET                        85AL300 FLARE                 0   0.000   2.855  21.3    0.273     0.0             1          AGR
11  16  30 10  4   SO2     STANMORE            RYERSON OIL & GAS LIMITED               PET               3887    83AL175 FLARE                 0   0.000   0.000  12.0    0.000     0.0             1          GRS
 7  20  40 10  4   SO2     PROVOST             SULPETRO LIMITED                        PET      FGP      4710    80AL154 FLARE    ACID GAS     0   0.000   0.400   0.0    0.000     0.0             4          AGR
*** Total ***
                                                                                                                                            0   0.948  35.849
```

Figure 8A. Sample report: Industrial Emission Sources - Basic Data.



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                                                                                 INDUSTRIAL EMISSION SOURCES - EMISSION DRIVER RATES

LSD SEC TWP RGE W#M EMISSION FACILITY             OPERATOR                                FACILITY APPROVAL LICENCE OPERAT'G EMISS'N QUALIFIER RATED EMISSION   DRIVER   DRIVER   DRIVER   DRIVER YEAR
                      TYPE    NAME                                                          TYPE    NUMBER  NUMBER   MODE    SOURCE  STATEMENT POWER  DRIVER    RATE     RATE     RATE     RATE
                                                                                                                              TYPE             LEVEL            1ST-1/4  2ND-1/4  3RD-1/4  4TH-1/4
                                                                                                                                                (KW)


NE  11  20  1  4   SO2    EMPRESS                 PETRO-CANADA INC                        FGP               83AL308 EMR      FLARE                0          0.000    0.000    0.000    0.000
NE  11  20  1  4   SO2    EMPRESS                 PETRO-CANADA INC                        FGP               83AL308 CON      FLARE   ACID GAS     0 N        1.000    1.000    1.000    1.000
 6   9  31  1  4   SO2    SIBBALD (ESTHER)        GULF CANADA RESOURCES INC               FGP      4677             EMR      FLARE                0          0.000    0.000    0.000    0.000
 6   9  31  1  4   SO2    SIBBALD (ESTHER)        GULF CANADA RESOURCES INC               FGP      4677             CON      FLARE   ACID GAS     0 G       65.321   21.366   15.086   55.670
NW   1  50  1  4   SO2    LLOYDMINSTER            HUSKY OIL OPERATIONS LTD                R                         CON      FLARE   ACID GAS     0 N        1.000    1.000    1.000    1.000
     6  66  1  4   SO2    PRIMROSE                NORCEN ENERGY RESOURCES LIMITED         HOP      2138             NCO      FLARE                0 N        1.000    1.000    1.000    1.000
 5   6  28  2  4   SO2    SIBBALD                 SUNCOR INC                                       2622     83AL067 EMR      FLARE                0          0.000    0.000    0.000    0.000
 4  31  30  2  4   SO2    HUDSON                  PETRODYNE LTD                                    3405     81AL569 EMR      FLARE                0          0.000    0.000    0.000    0.000
 6  36  33  2  4   SO2    COMPEER                 WESTERN DECALTA PETROLEUM (1977) LTD    FGP      3903     83AL196 CON      FLARE   ACID GAS     0 G        0.000   61.069   62.701   43.125
10  35  42  2  4   SO2    CHAUVIN SOUTH           TURALTA RESOURCES LTD                   EGP      4689     85AL359 EMR      FLARE                0          0.000    0.000    0.000    0.000
10  35  42  2  4   SO2    CHAUVIN SOUTH           TURALTA RESOURCES LTD                   EGP      4689     85AL359 CON      INCIN   SRU          0 S        0.000    0.000    0.000    0.000
10  28  28  3  4   SO2    BENTON                  DORCHESTER EXPLORATION INC              FGP      4421     84AL313 CON      FLARE   ACID GAS     0          0.000    0.000    0.000    0.000
15  26  40  3  4   SO2    DAVID                   OCELOT INDUSTRIES LTD                   OB       4313             CON      FLARE                0 N        1.000    1.000    1.000    1.000
10  22  64  3  4   SO2    MAY-ETHEL               ESSO RESOURCES CANADA LIMITED           HOP      3369             NCO      INC                  0 N        1.000    1.000    1.000    1.000
NW   5  65  3  4   SO2    LEMING                  ESSO RESOURCES CANADA LIMITED           HOP      2943             NCO      FLARE                0 N        1.000    1.000    1.000    1.000
10   3  35  4  4   SO2    MONITOR                 ALTANA EXPLORATION COMPANY              FGP      3973     83AL231 CON      FLARE   ACID GAS     0          0.000    0.000    0.000    0.000
NW  15   5  5  4   SO2    MANYBERRIES             CANAM FINANCIAL GROUP LTD                        4645     85AL092 EMR      FLARE                0          0.000    0.000    0.000    0.000
     7  13  5  4   SO2    MEDICINE HAT            WESTERN CO-OPERATIVE FERTILIZERS LIMITED FP                       NCO      INCIN   H2SO4 PLT    0 N        1.000    1.000    1.000    1.000
 5  18  38  5  4   SO2    PROVOST NORTH           DOME PETROLEUM LIMITED                  OB                81AL609 EMR      FLARE                0 N        1.000    1.000    1.000    1.000
 6  18   6  6  4   SO2    MANYBERRIES             CIMARRON PETROLEUM LTD                  FGP      3595     82AL379 CON      FLARE   ACID GAS     0 G       38.778   25.102    5.741    0.000
     1  65  6  4   SO2    MARGUERITE LAKE         B P CANADA INC                          HOP      2337             NCO      FLARE                0 N        1.000    1.000    1.000    1.000
 8   5  22  7  4   SO2    ATLEE-BUFFALO           ZAG INVESTMENTS LTD (ARIES)                               85AL236 EMR      FLARE                0          0.000    0.000    0.000    0.000
11  14  39  7  4   SO2    PROVOST                 CARLYLE ENERGY LTD                      FGP      3885     83AL176 CON      FLARE   ACID GAS     0 G        8.750    0.262    0.000    0.000
SW   7  77  7  4   SO2    LEISMER EAST            HOME OIL COMPANY LIMITED                                  84AL200 EMR      FLARE                0          0.000    0.000    0.000    0.000
 5   2  86  7  4   SO2    GREGOIRE LAKE           AMOCO CANADA PETROLEUM COMPANY LTD      HOP      4281             NCO      FLARE                0 N        1.000    1.000    1.000    1.000
SE  18   1  8  4   SO2    BLACK BUTTE             CANADIAN MONTANA GAS CO LTD             FGP      3506     82AL162 NCO      FLARE   ACID GAS     0          0.000    0.000    0.000    0.000
10   5  39  8  4   SO2    PROVOST                 RANCHMEN'S RESOURCES (1976) LTD                  3510     82AL114 EMR      FLARE                0          0.000    0.000    0.000    0.000
    15  88  8  4   SO2    ATHABASCA               TEXACO CANADA RESOURCES LTD             HOP      3070             NCO      FLARE                0 N        1.000    1.000    1.000    1.000
10  34  19  9  4   SO2    JENNER                  DOME PETROLEUM LIMITED                  FGP      4403     84AL267 CON      FLARE   ACID GAS     0          0.000    0.000    0.000    0.000
11  29  30  9  4   SO2    SOUNDING                UNOCAL CANADA LTD                                3386     81AL419 EMR      FALRE                0          0.000    0.000    0.000    0.000
NW  17  40  9  4   SO2    CHOICE                  DOME PETROLEUM LIMITED                                    81AL283 EMR      FLARE                0          0.000    0.000    0.000    0.000
10  21  40  9  4   SO2    CHOICE (PROVOST)        DOME PETROLEUM LIMITED                  FGP      4436     85AL115 NCO      FLARE   ACID GAS     0          0.000    0.000    0.000    0.000
15  11  43  9  4   SO2    HARDISTY                VOYAGER PETROLEUMS (II) LTD                      C1039    85AL421 EMR      FLARE                0          0.000    0.000    0.000    0.000
 4   5  44  9  4   SO2    KILLAM (HAWKINS)        RANGER OIL LIMITED                               2487     82AL345 EMR      FLARE                0          0.000    0.000    0.000    0.000
16  20  61  9  4   SO2    ASHMONT                 WINTERSHALL OIL OF CANADA LTD                             81AL446 EMR      FLARE                0          0.000    0.000    0.000    0.000
12   1  16 10  4   SO2    ALDERSON                PETRO-CANADA INC                                          81AL243 EMR      FLARE                0          0.000    0.000    0.000    0.000
NW  14  17 10  4   SO2    MONOGRAM                OCELOT INDUSTRIES LTD                                     82AL349 EMR      FLARE                0          0.000    0.000    0.000    0.000
16  10  18 10  4   SO2    TIDE LAKE               PANCANADIAN PETROLEUM LIMITED                             85AL300 EMR      FLARE                0          0.000    0.000    0.000    0.000
11  16  30 10  4   SO2    STANMORE                RYERSON OIL & GAS LIMITED                        3887     83AL175 EMR      FLARE                0          0.000    0.000    0.000    0.000
 7  20  40 10  4   SO2    PROVOST                 SULPETRO LIMITED                        FGP      4710     80AL154 CON      FLARE   ACID GAS     0 G       34.882    0.000    9.899   34.468
*** Total ***

                                                                                                                                                0         158.731  118.799  104.427  144.263
```

Figure 8B. Sample report: Industrial Emission Sources - Emission Driver Rates.

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                                                    INDUSTRIAL EMISSION SOURCES - EMISSION FACTORS

LSD SEC TWP RGE W#M EMISSION FACILITY            OPERATOR                                 INDUSTRY FACILITY APPROVAL LICENCE  TYPE  QUALIFIER  RATED  TYPE     EMISSION EMISSION  SOURCE    YEAR ECOREGION ENVIRONMENTAL
                    TYPE     NAME                                                                  TYPE     NUMBER   NUMBER   OF    STATEMENT  POWER   OF       FACTOR   FACTOR    OF                        SETTING
                                                                                                                           EMISSION            LEVEL EMISSION          PRECISION EMISSION
                                                                                                                            SOURCE             (KW)  DRIVER                        FACTOR


 NE  11  20   1   4 SO2      EMPRESS              PETRO-CANADA INC                         PET      FGP               83AL308 FLARE              0          0.00000   0.000                1         GRS
 NE  11  20   1   4 SO2      EMPRESS              PETRO-CANADA INC                         PET      FGP               83AL308 FLARE  ACID GAS    0 N        0.15700   0.452 EVA       1983 1         GRS
  6   9  31   1   4 SO2      SIBBALD (ESTHER)     GULF CANADA RESOURCES INC                PET      FGP     4677              FLARE              0          0.00000   0.000                2         GRS
  6   9  31   1   4 SO2      SIBBALD (ESTHER)     GULF CANADA RESOURCES INC                PET      FGP     4677              FLARE  ACID GAS    0 G        0.00000   0.000                2         GRS
 NW   1  50   1   4 SO2      LLOYDMINSTER         HUSKY OIL OPERATIONS LTD                 PET      R                           FLARE  ACID GAS    0 N        0.00000   0.000 EST            4         AGR
      6  66   1   4 SO2      PRIMROSE             NORCEN ENERGY RESOURCES LIMITED          PET      HOP     2138              FLARE              0 N        0.00000   0.000                8         FRT
  5   6  28   2   4 SO2      SIBBALD              SUNCOR INC                               PET              2622      83AL067 FLARE              0          0.00000   0.000                2         AGR
  4  31  30   2   4 SO2      HUDSON               PETRODYNE LTD                            PET              3405      81AL569 FLARE              0          0.00000   0.000                2         AGR
  6  36  33   2   4 SO2      COMPEER              WESTERN DECALTA PETROLEUM (1977) LTD     PET      FGP     3903      83AL196 FLARE  ACID GAS    0 G        0.00000   0.000                2         AGR
 10  35  42   2   4 SO2      CHAUVIN SOUTH        TURALTA RESOURCES LTD                    PET      EGP     4689      85AL359 FLARE              0          0.00000   0.000                4         AGR
 10  35  42   2   4 SO2      CHAUVIN SOUTH        TURALTA RESOURCES LTD                    PET      EGP     4689      85AL359 INCIN  SRU         0 S        0.00000   0.000                4         AGR
 10  28  28   3   4 SO2      BENTON               DORCHESTER EXPLORATION INC               PET      FGP     4421      84AL313 FLARE  ACID GAS    0          0.00000   0.000                2         AGR
 15  26  40   3   4 SO2      DAVID                OCELOT INDUSTRIES LTD                    PET      OB      4313              FLARE              0 N        0.79100   0.440 EVA       1983 4         AGR
 10  22  64   3   4 SO2      MAY-ETHEL            ESSO RESOURCES CANADA LIMITED            PET      HOP     3369              INC                0 N        0.00000   0.000 EST            8         FRT
 NW   5  65   3   4 SO2      LEMING               ESSO RESOURCES CANADA LIMITED            PET      HOP     2943              FLARE              0 N        0.00000   0.000 EST            8         FRT
 10   3  35   4   4 SO2      MONITOR              ALTANA EXPLORATION COMPANY               PET      FGP     3973      83AL231 FLARE  ACID GAS    0          0.00000   0.000                2         AGR
 NW  15   5   5   4 SO2      MANYBERRIES          CANAM FINANCIAL GROUP LTD                PET              4645      85AL092 FLARE              0          0.00000   0.000                1         GRS
      7  13   5   4 SO2      MEDICINE HAT         WESTERN CO-OPERATIVE FERTILIZERS LIMITED FER      FP                        INCIN  H2SO4 PLT   0 N        0.00000   0.000                1         URB
  5  18  38   5   4 SO2      PROVOST NORTH        DOME PETROLEUM LIMITED                   PET      OB                81AL609 FLARE              0 N        0.00000   0.000                4         AGR
  6  18   6   6   4 SO2      MANYBERRIES          CIMARRON PETROLEUM LTD                   PET      FGP     3595      82AL379 FLARE  ACID GAS    0 G        0.00000   0.000                1         GRS
      1  65   6   4 SO2      MARGUERITE LAKE      B P CANADA INC                           PET      HOP     2337              FLARE              0 N        0.00000   0.000 EST            8         FRT
  8   5  22   7   4 SO2      ATLEE-BUFFALO        ZAG INVESTMENTS LTD (ARIES)              PET                        85AL236 FLARE              0          0.00000   0.000                1         GRS
 11  14  39   7   4 SO2      PROVOST              CARLYLE ENERGY LTD                       PET      FGP     3885      83AL176 FLARE  ACID GAS    0 G        0.00000   0.000                4         AGR
 SW   7  77   7   4 SO2      LEISMER EAST         HOME OIL COMPANY LIMITED                 PET                        84AL200 FLARE              0          0.00000   0.000                8         MUS
  5   2  86   7   4 SO2      GREGOIRE LAKE        AMOCO CANADA PETROLEUM COMPANY LTD       PET      HOP     4281              FLARE              0 N        0.00000   0.000 EST            8         FRT
 SE  18   1   8   4 SO2      BLACK BUTTE          CANADIAN MONTANA GAS CO LTD              PET      FGP     3506      82AL162 FLARE  ACID GAS    0          0.00000   0.000                2         GRS
 10   5  39   8   4 SO2      PROVOST              RANCHMEN'S RESOURCES (1976) LTD          PET              3510      82AL114 FLARE              0          0.00000   0.000                4         AGR
     15  88   8   4 SO2      ATHABASCA            TEXACO CANADA RESOURCES LTD              PET      HOP     3070              FLARE              0 N        0.00000   0.000 EST            8         FRT
 10  34  19   9   4 SO2      JENNER               DOME PETROLEUM LIMITED                   PET      FGP     4403      84AL267 FLARE  ACID GAS    0          0.00000   0.000                1         AGR
 11  29  30   9   4 SO2      SOUNDING             UNOCAL CANADA LTD                        PET              3386      81AL419 FALRE              0          0.00000   0.000                1         AGR
 NW  17  40   9   4 SO2      CHOICE               DOME PETROLEUM LIMITED                   PET                        81AL283 FLARE              0          0.00000   0.000                4         AGR
 10  21  40   9   4 SO2      CHOICE (PROVOST)     DOME PETROLEUM LIMITED                   PET      FGP     4436      85AL115 FLARE  ACID GAS    0          0.00000   0.000                4         AGR
 15  11  43   9   4 SO2      HARDISTY             VOYAGER PETROLEUMS (II) LTD              PET              C1039     85AL421 FLARE              0          0.00000   0.000                4         AGR
  4   5  44   9   4 SO2      KILLAM (HAWKINS)     RANGER OIL LIMITED                       PET              2487      82AL345 FLARE              0          0.00000   0.000                4         AGR
 16  20  61   9   4 SO2      ASHMONT              WINTERSHALL OIL OF CANADA LTD            PET                        81AL446 FLARE              0          0.00000   0.000                8         AGR
 12   1  16  10   4 SO2      ALDERSON             PETRO-CANADA INC                         PET                        81AL243 FLARE              0          0.00000   0.000                1         GRS
 NW  14  17  10   4 SO2      MONOGRAM             OCELOT INDUSTRIES LTD                    PET                        82AL349 FLARE              0          0.00000   0.000                1         GRS
 16  10  18  10   4 SO2      TIDE LAKE            PANCANADIAN PETROLEUM LIMITED            PET                        85AL300 FLARE              0          0.00000   0.000                1         AGR
 11  16  30  10   4 SO2      STANMORE             RYERSON OIL & GAS LIMITED                PET              3887      83AL175 FLARE              0          0.00000   0.000                1         GRS
  7  20  40  10   4 SO2      PROVOST              SULPETRO LIMITED                         PET      FGP     4710      80AL154 FLARE  ACID GAS    0 G        0.00000   0.000                4         AGR
### Total ###

                                                                                                                                                   0
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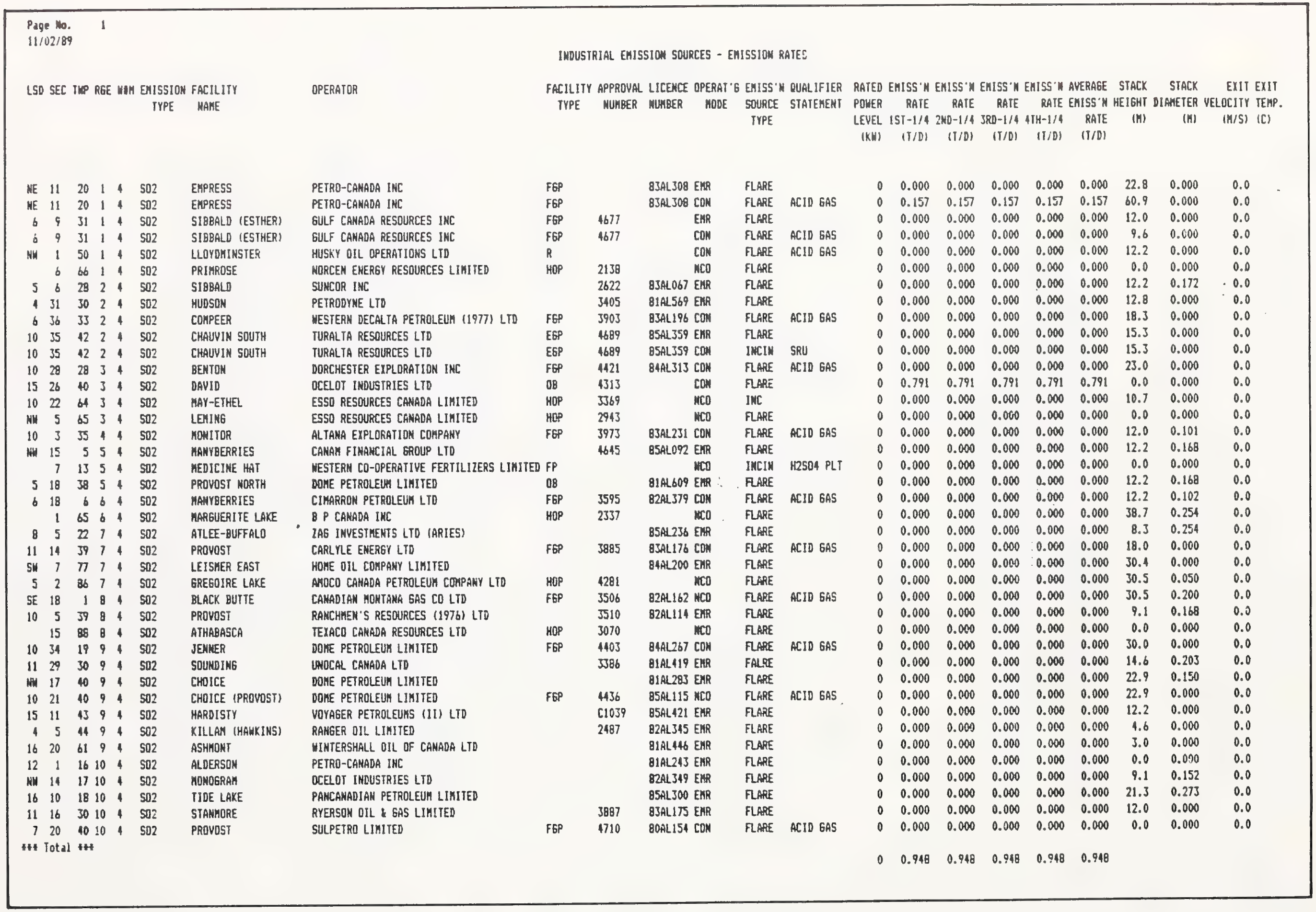
Figure 8C. Sample report: Industrial Emission Sources - Emission Factors.



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                                                                                        INDUSTRIAL EMISSION SOURCES - EMISSION RATES

LSD SEC TWP RGE W#M EMISSION FACILITY          OPERATOR                                 FACILITY APPROVAL LICENCE OPERAT'G EMISS'N QUALIFIER RATED EMISS'N EMISS'N EMISS'N EMISS'N AVERAGE  STACK    STACK     EXIT EXIT
                      TYPE     NAME                                                       TYPE     NUMBER  NUMBER     MODE  SOURCE STATEMENT POWER    RATE    RATE    RATE    RATE EMISS'N HEIGHT DIAMETER VELOCITY TEMP.
                                                                                                                              TYPE           LEVEL 1ST-1/4 2ND-1/4 3RD-1/4 4TH-1/4    RATE    (M)      (M)    (M/S) (C)
                                                                                                                                              (KW)   (T/D)   (T/D)   (T/D)   (T/D)   (T/D)


 NE  11  20   1   4  SO2     EMPRESS           PETRO-CANADA INC                         FGP               83AL308 EMR      FLARE                 0   0.000   0.000   0.000   0.000   0.000   22.8    0.000      0.0
 NE  11  20   1   4  SO2     EMPRESS           PETRO-CANADA INC                         FGP               83AL308 CON      FLARE   ACID GAS      0   0.157   0.157   0.157   0.157   0.157   60.9    0.000      0.0
  6   9  31   1   4  SO2     SIBBALD (ESTHER)  GULF CANADA RESOURCES INC                FGP          4677         EMR      FLARE                 0   0.000   0.000   0.000   0.000   0.000   12.0    0.000      0.0
  6   9  31   1   4  SO2     SIBBALD (ESTHER)  GULF CANADA RESOURCES INC                FGP          4677         CON      FLARE   ACID GAS      0   0.000   0.000   0.000   0.000   0.000    9.6    0.000      0.0
 NW   1  50   1   4  SO2     LLOYDMINSTER      HUSKY OIL OPERATIONS LTD                 R                         CON      FLARE   ACID GAS      0   0.000   0.000   0.000   0.000   0.000   12.2    0.000      0.0
      6  66   1   4  SO2     PRIMROSE          NORCEN ENERGY RESOURCES LIMITED          HOP          2138         NCO      FLARE                 0   0.000   0.000   0.000   0.000   0.000    0.0    0.000      0.0
  5   6  28   2   4  SO2     SIBBALD           SUNCOR INC                                            2622 83AL067 EMR      FLARE                 0   0.000   0.000   0.000   0.000   0.000   12.2    0.172      0.0
  4  31  30   2   4  SO2     HUDSON            PETRODYNE LTD                                         3405 81AL569 EMR      FLARE                 0   0.000   0.000   0.000   0.000   0.000   12.8    0.000      0.0
  6  36  33   2   4  SO2     COMPEER           WESTERN DECALTA PETROLEUM (1977) LTD     FGP          3903 83AL196 CON      FLARE   ACID GAS      0   0.000   0.000   0.000   0.000   0.000   18.3    0.000      0.0
 10  35  42   2   4  SO2     CHAUVIN SOUTH     TURALTA RESOURCES LTD                    EGP          4689 85AL359 EMR      FLARE                 0   0.000   0.000   0.000   0.000   0.000   15.3    0.000      0.0
 10  35  42   2   4  SO2     CHAUVIN SOUTH     TURALTA RESOURCES LTD                    EGP          4689 85AL359 CON      INCIN   SRU           0   0.000   0.000   0.000   0.000   0.000   15.3    0.000      0.0
 10  28  28   3   4  SO2     BENTON            DORCHESTER EXPLORATION INC               FGP          4421 84AL313 CON      FLARE   ACID GAS      0   0.000   0.000   0.000   0.000   0.000   23.0    0.000      0.0
 15  26  40   3   4  SO2     DAVID             OCELOT INDUSTRIES LTD                    OB           4313         CON      FLARE                 0   0.791   0.791   0.791   0.791   0.791    0.0    0.000      0.0
 10  22  64   3   4  SO2     MAY-ETHEL         ESSO RESOURCES CANADA LIMITED            HOP          3369         NCO      INC                   0   0.000   0.000   0.000   0.000   0.000   10.7    0.000      0.0
 NW   5  65   3   4  SO2     LEMING            ESSO RESOURCES CANADA LIMITED            HOP          2943         NCO      FLARE                 0   0.000   0.000   0.000   0.000   0.000    0.0    0.000      0.0
 10   3  35   4   4  SO2     MONITOR           ALTANA EXPLORATION COMPANY               FGP          3973 83AL231 CON      FLARE   ACID GAS      0   0.000   0.000   0.000   0.000   0.000   12.0    0.101      0.0
 NW  15   5   5   4  SO2     MANYBERRIES       CANAM FINANCIAL GROUP LTD                             4645 85AL092 EMR      FLARE                 0   0.000   0.000   0.000   0.000   0.000   12.2    0.168      0.0
      7  13   5   4  SO2     MEDICINE HAT      WESTERN CO-OPERATIVE FERTILIZERS LIMITED FP                        NCO      INCIN   H2SO4 PLT     0   0.000   0.000   0.000   0.000   0.000    0.0    0.000      0.0
  5  18  38   5   4  SO2     PROVOST NORTH     DOME PETROLEUM LIMITED                   OB                81AL609 EMR      FLARE                 0   0.000   0.000   0.000   0.000   0.000   12.2    0.168      0.0
  6  18   6   6   4  SO2     MANYBERRIES       CIMARRON PETROLEUM LTD                   FGP          3595 82AL379 CON      FLARE   ACID GAS      0   0.000   0.000   0.000   0.000   0.000   12.2    0.102      0.0
      1  65   6   4  SO2     MARGUERITE LAKE   B P CANADA INC                           HOP          2337         NCO      FLARE                 0   0.000   0.000   0.000   0.000   0.000   38.7    0.254      0.0
  8   5  22   7   4  SO2     ATLEE-BUFFALO     ZAG INVESTMENTS LTD (ARIES)                                85AL236 EMR      FLARE                 0   0.000   0.000   0.000   0.000   0.000    8.3    0.254      0.0
 11  14  39   7   4  SO2     PROVOST           CARLYLE ENERGY LTD                       FGP          3885 83AL176 CON      FLARE   ACID GAS      0   0.000   0.000   0.000   0.000   0.000   18.0    0.000      0.0
 SW   7  77   7   4  SO2     LEISMER EAST      HOME OIL COMPANY LIMITED                                   84AL200 EMR      FLARE                 0   0.000   0.000   0.000   0.000   0.000   30.4    0.000      0.0
  5   2  86   7   4  SO2     GREGOIRE LAKE     AMOCO CANADA PETROLEUM COMPANY LTD       HOP          4281         NCO      FLARE                 0   0.000   0.000   0.000   0.000   0.000   30.5    0.050      0.0
 SE  18   1   8   4  SO2     BLACK BUTTE       CANADIAN MONTANA GAS CO LTD              FGP          3506 82AL162 NCO      FLARE   ACID GAS      0   0.000   0.000   0.000   0.000   0.000   30.5    0.200      0.0
 10   5  39   8   4  SO2     PROVOST           RANCHMEN'S RESOURCES (1976) LTD                       3510 82AL114 EMR      FLARE                 0   0.000   0.000   0.000   0.000   0.000    9.1    0.168      0.0
     15  86   8   4  SO2     ATHABASCA         TEXACO CANADA RESOURCES LTD              HOP          3070         NCO      FLARE                 0   0.000   0.000   0.000   0.000   0.000    0.0    0.000      0.0
 10  34  19   9   4  SO2     JENNER            DOME PETROLEUM LIMITED                   FGP          4403 84AL267 CON      FLARE   ACID GAS      0   0.000   0.000   0.000   0.000   0.000   30.0    0.000      0.0
 11  29  30   9   4  SO2     SOUNDING          UNOCAL CANADA LTD                                     3386 81AL419 EMR      FALRE                 0   0.000   0.000   0.000   0.000   0.000   14.6    0.203      0.0
 NW  17  40   9   4  SO2     CHOICE            DOME PETROLEUM LIMITED                                     81AL283 EMR      FLARE                 0   0.000   0.000   0.000   0.000   0.000   22.9    0.150      0.0
 10  21  40   9   4  SO2     CHOICE (PROVOST)  DOME PETROLEUM LIMITED                   FGP          4436 85AL115 NCO      FLARE   ACID GAS      0   0.000   0.000   0.000   0.000   0.000   22.9    0.000      0.0
 15  11  43   9   4  SO2     HARDISTY          VOYAGER PETROLEUMS (II) LTD                          C1039 85AL421 EMR      FLARE                 0   0.000   0.000   0.000   0.000   0.000   12.2    0.000      0.0
  4   5  44   9   4  SO2     KILLAM (HAWKINS)  RANGER OIL LIMITED                                    2487 82AL345 EMR      FLARE                 0   0.000   0.000   0.000   0.000   0.000    4.6    0.000      0.0
 16  20  61   9   4  SO2     ASHMONT           WINTERSHALL OIL OF CANADA LTD                              81AL446 EMR      FLARE                 0   0.000   0.000   0.000   0.000   0.000    3.0    0.000      0.0
 12   1  16  10   4  SO2     ALDERSON          PETRO-CANADA INC                                           81AL243 EMR      FLARE                 0   0.000   0.000   0.000   0.000   0.000    0.0    0.000      0.0
 NW  14  17  10   4  SO2     MONOGRAM          OCELOT INDUSTRIES LTD                                      82AL349 EMR      FLARE                 0   0.000   0.000   0.000   0.000   0.000    9.1    0.152      0.0
 16  10  18  10   4  SO2     TIDE LAKE         PANCANADIAN PETROLEUM LIMITED                              85AL300 EMR      FLARE                 0   0.000   0.000   0.000   0.000   0.000   21.3    0.273      0.0
 11  16  30  10   4  SO2     STANMORE          RYERSON OIL & GAS LIMITED                             3887 83AL175 EMR      FLARE                 0   0.000   0.000   0.000   0.000   0.000   12.0    0.000      0.0
  7  20  40  10   4  SO2     PROVOST           SULPETRO LIMITED                         FGP          4710 80AL154 CON      FLARE   ACID GAS      0   0.000   0.000   0.000   0.000   0.000    0.0    0.000      0.0
### Total ###
                                                                                                                                                 0   0.948   0.948   0.948   0.948   0.948
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Figure 8D. Sample report: Industrial Emission Sources - Emission Rates.

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                                                                        URBAN CENTRE EMISSION SOURCES - BASIC DATA

SEC TWP RGE W#M NAME            TYPE     AREA POPULATION YEAR URBAN    ANNUAL ELEVATION ECOREGION
                                         (HA)                 I.D.   EMISSION   (M)
                                                              CODE     RATE
                                                              (1-6)    (T/D)


12  27  1   5   AIRDRIE         CTY   1360.00   10431    1984 S        0.494 1082      3
6   24  1   5   CALGARY         CTY  52721.00  619814    1984 CAL     35.371 1058      3
34  46  20  4   CAMROSE         CTY   2460.00   12751    1984 N        0.713 675       4
1   29  20  4   DRUMHELLER      CTY   1615.00    6671    1984 S        0.316 687       2
1   53  25  4   EDMONTON        CTY  63066.00  560085    1984 EDM     36.479 658       4
16  89  9   4   FORT MCMURRAY   CTY   6007.37   35352    1984 FGS      1.371 369       8
24  71  6   6   GRAND PRAIRIE   CTY   4079.00   24411    1984 FGS      0.947 652       6
25  49  25  4   LEDUC           CTY   7416.00   12471    1984 N        0.697           4
31  8   21  4   LETHBRIDGE      CTY   6535.00   58586    1984 LMH      3.245 903       2
31  12  5   4   MEDICINE HAT    CTY   6272.00   41493    1984 LMH      2.298 717       1
21  38  27  4   RED DEER        CTY   5180.00   51070    1984 RED      3.121 860       4
3   54  25  4   ST. ALBERT      CTY   3560.00   35529    1984 FGS      1.378           4
14  46  24  4   WETASKIWIN      CTY   1130.00   10022    1984 N        0.560 756       4
16  66  22  4   ATHABASCA       TWN   1423.00    1862    1984 N        0.104 518       8
20  59  3   5   BARRHEAD        TWN    777.00    3849    1984 N        0.215 644       8
4   42  21  4   BASHAW          TWN    282.20     875    1984 N        0.049 792       4
17  21  18  4   BASSANO         TWN    483.60    1200    1984 S        0.057 800       2
26  50  24  4   BEAUMONT        TWN    370.00    3468    1984 N        0.194           4
2   72  10  6   BEAVERLODGE     TWN    495.00    1937    1984 N        0.108 732       8
8   20  2   5   BLACK DIAMOND   TWN    192.86    1545    1984 S        0.073           4
27  39  27  4   BLACKFALDS      TWN    255.32    1614    1984 N        0.090 875       4
12  56  24  4   BON ACCORD      TWN    203.31    1425    1984 N        0.080           4
18  61  5   4   BONNYVILLE      TWN   1211.96    4786    1984 N        0.267 549       8
35  10  11  4   BOW ISLAND      TWN    309.30    1499    1984 S        0.071 799       1
23  34  1   5   BOWDEN          TWN    122.03    1021    1984 S        0.048 915       4
32  18  14  4   BROOKS          TWN   1549.72    9421    1984 S        0.446 758       1
33  55  20  4   BRUDERHEIM      TWN    455.00    1238    1984 N        0.069 640       4
25  49  27  4   CALMER          TWN    192.00    1137    1984 N        0.064 716       4
32  24  10  5   CANMORE         TWN   1961.00    4012    1984 S        0.190 1309      6
9   3   25  4   CARDSTON        TWN    612.41    3546    1984 S        0.168 1166      3
17  30  1   5   CARSTAIRS       TWN    139.00    1725    1984 S        0.082           4
34  37  14  4   CASTOR          TWN    272.75    1123    1984 S        0.053 770       4
26  12  27  4   CLARESHOLM      TWN    524.69    3493    1984 S        0.165 1033      2
10  9   20  4   COAL DALE       TWN    442.42    4768    1984 S        0.226 862       2
3   26  4   5   COCHRANE        TWN   1800.00    4044    1984 S        0.191 1280      4
19  63  1   4   COLD LAKE       TWN    769.72    2515    1984 N        0.141 541       8
13  36  11  4   CORONATION      TWN    369.00    1268    1984 S        0.060 798       2
26  28  1   5   CROSSFIELD      TWN    371.50    1428    1984 S        0.068 1128      3
12  8   6   5   CROWSNEST PASS  TWN  14913.00    7577    1984 S        0.359           5
9   45  16  4   DAYSLAND        TWN    165.80     709    1984 N        0.040 689       4
*** Total ***
                                     ********                         90.668
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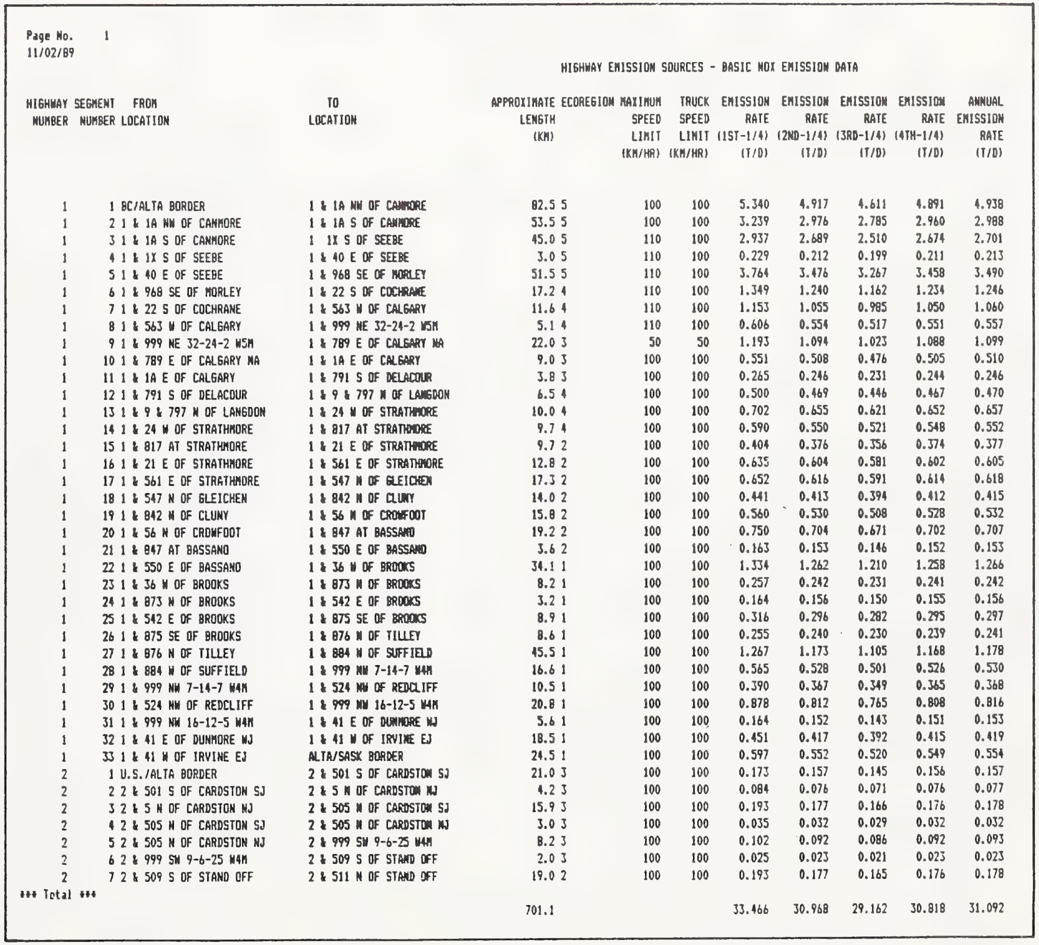
Figure 8E. Sample report: Urban Centre Sources - Basic Data.



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                                                                  HIGHWAY EMISSION SOURCES - BASIC NOX EMISSION DATA

HIGHWAY SEGMENT   FROM                          TO                          APPROXIMATE ECOREGION MAXIMUM   TRUCK  EMISSION  EMISSION  EMISSION  EMISSION    ANNUAL
 NUMBER  NUMBER LOCATION                      LOCATION                         LENGTH               SPEED   SPEED      RATE      RATE      RATE      RATE  EMISSION
                                                                                 (KM)               LIMIT   LIMIT (1ST-1/4) (2ND-1/4) (3RD-1/4) (4TH-1/4)      RATE
                                                                                                  (KM/HR) (KM/HR)     (T/D)     (T/D)     (T/D)     (T/D)     (T/D)


      1       1 BC/ALTA BORDER                1 & 1A NW OF CANMORE               82.5 5             100     100     5.340     4.917     4.611     4.891     4.938
      1       2 1 & 1A NW OF CANMORE          1 & 1A S OF CANMORE                53.5 5             100     100     3.239     2.976     2.785     2.960     2.988
      1       3 1 & 1A S OF CANMORE           1  1X S OF SEEBE                   45.0 5             110     100     2.937     2.689     2.510     2.674     2.701
      1       4 1 & 1X S OF SEEBE             1 & 40 E OF SEEBE                   3.0 5             110     100     0.229     0.212     0.199     0.211     0.213
      1       5 1 & 40 E OF SEEBE             1 & 968 SE OF MORLEY               51.5 5             110     100     3.764     3.476     3.267     3.458     3.490
      1       6 1 & 968 SE OF MORLEY          1 & 22 S OF COCHRANE               17.2 4             110     100     1.349     1.240     1.162     1.234     1.246
      1       7 1 & 22 S OF COCHRANE          1 & 563 W OF CALGARY               11.6 4             110     100     1.153     1.055     0.985     1.050     1.060
      1       8 1 & 563 W OF CALGARY          1 & 999 NE 32-24-2 W5M              5.1 4             110     100     0.606     0.554     0.517     0.551     0.557
      1       9 1 & 999 NE 32-24-2 W5M        1 & 789 E OF CALGARY NA            22.0 3              50      50     1.193     1.094     1.023     1.088     1.099
      1      10 1 & 789 E OF CALGARY NA       1 & 1A E OF CALGARY                 9.0 3             100     100     0.551     0.508     0.476     0.505     0.510
      1      11 1 & 1A E OF CALGARY           1 & 791 S OF DELACOUR               3.8 3             100     100     0.265     0.246     0.231     0.244     0.246
      1      12 1 & 791 S OF DELACOUR         1 & 9 & 797 N OF LANGDON            6.5 4             100     100     0.500     0.469     0.446     0.467     0.470
      1      13 1 & 9 & 797 N OF LANGDON      1 & 24 W OF STRATHMORE             10.0 4             100     100     0.702     0.655     0.621     0.652     0.657
      1      14 1 & 24 W OF STRATHMORE        1 & 817 AT STRATHMORE               9.7 4             100     100     0.590     0.550     0.521     0.548     0.552
      1      15 1 & 817 AT STRATHMORE         1 & 21 E OF STRATHMORE              9.7 2             100     100     0.404     0.376     0.356     0.374     0.377
      1      16 1 & 21 E OF STRATHMORE        1 & 561 E OF STRATHMORE            12.8 2             100     100     0.635     0.604     0.581     0.602     0.605
      1      17 1 & 561 E OF STRATHMORE       1 & 547 N OF GLEICHEN              17.3 2             100     100     0.652     0.616     0.591     0.614     0.618
      1      18 1 & 547 N OF GLEICHEN         1 & 842 N OF CLUNY                 14.0 2             100     100     0.441     0.413     0.394     0.412     0.415
      1      19 1 & 842 N OF CLUNY            1 & 56 N OF CROWFOOT               15.8 2             100     100     0.560     0.530     0.508     0.528     0.532
      1      20 1 & 56 N OF CROWFOOT          1 & 847 AT BASSANO                 19.2 2             100     100     0.750     0.704     0.671     0.702     0.707
      1      21 1 & 847 AT BASSANO            1 & 550 E OF BASSANO                3.6 2             100     100     0.163     0.153     0.146     0.152     0.153
      1      22 1 & 550 E OF BASSANO          1 & 36 W OF BROOKS                 34.1 1             100     100     1.334     1.262     1.210     1.258     1.266
      1      23 1 & 36 W OF BROOKS            1 & 873 N OF BROOKS                 8.2 1             100     100     0.257     0.242     0.231     0.241     0.242
      1      24 1 & 873 N OF BROOKS           1 & 542 E OF BROOKS                 3.2 1             100     100     0.164     0.156     0.150     0.155     0.156
      1      25 1 & 542 E OF BROOKS           1 & 875 SE OF BROOKS                8.9 1             100     100     0.316     0.296     0.282     0.295     0.297
      1      26 1 & 875 SE OF BROOKS          1 & 876 N OF TILLEY                 8.6 1             100     100     0.255     0.240     0.230     0.239     0.241
      1      27 1 & 876 N OF TILLEY           1 & 884 W OF SUFFIELD              45.5 1             100     100     1.267     1.173     1.105     1.168     1.178
      1      28 1 & 884 W OF SUFFIELD         1 & 999 NW 7-14-7 W4M              16.6 1             100     100     0.565     0.528     0.501     0.526     0.530
      1      29 1 & 999 NW 7-14-7 W4M         1 & 524 NW OF REDCLIFF             10.5 1             100     100     0.390     0.367     0.349     0.365     0.368
      1      30 1 & 524 NW OF REDCLIFF        1 & 999 NW 16-12-5 W4M             20.8 1             100     100     0.878     0.812     0.765     0.808     0.816
      1      31 1 & 999 NW 16-12-5 W4M        1 & 41 E OF DUNMORE WJ              5.6 1             100     100     0.164     0.152     0.143     0.151     0.153
      1      32 1 & 41 E OF DUNMORE WJ        1 & 41 W OF IRVINE EJ              18.5 1             100     100     0.451     0.417     0.392     0.415     0.419
      1      33 1 & 41 W OF IRVINE EJ         ALTA/SASK BORDER                   24.5 1             100     100     0.597     0.552     0.520     0.549     0.554
      2       1 U.S./ALTA BORDER              2 & 501 S OF CARDSTON SJ           21.0 3             100     100     0.173     0.157     0.145     0.156     0.157
      2       2 2 & 501 S OF CARDSTON SJ      2 & 5 N OF CARDSTON NJ              4.2 3             100     100     0.084     0.076     0.071     0.076     0.077
      2       3 2 & 5 N OF CARDSTON NJ        2 & 505 N OF CARDSTON SJ           15.9 3             100     100     0.193     0.177     0.166     0.176     0.178
      2       4 2 & 505 N OF CARDSTON SJ      2 & 505 N OF CARDSTON NJ            3.0 3             100     100     0.035     0.032     0.029     0.032     0.032
      2       5 2 & 505 N OF CARDSTON NJ      2 & 999 SW 9-6-25 W4M               8.2 3             100     100     0.102     0.092     0.086     0.092     0.093
      2       6 2 & 999 SW 9-6-25 W4M         2 & 509 S OF STAND OFF              2.0 3             100     100     0.025     0.023     0.021     0.023     0.023
      2       7 2 & 509 S OF STAND OFF        2 & 511 N OF STAND OFF             19.0 2             100     100     0.193     0.177     0.165     0.176     0.178
*** Total ***
                                                                                 701.1                              33.466    30.968    29.162    30.818    31.092
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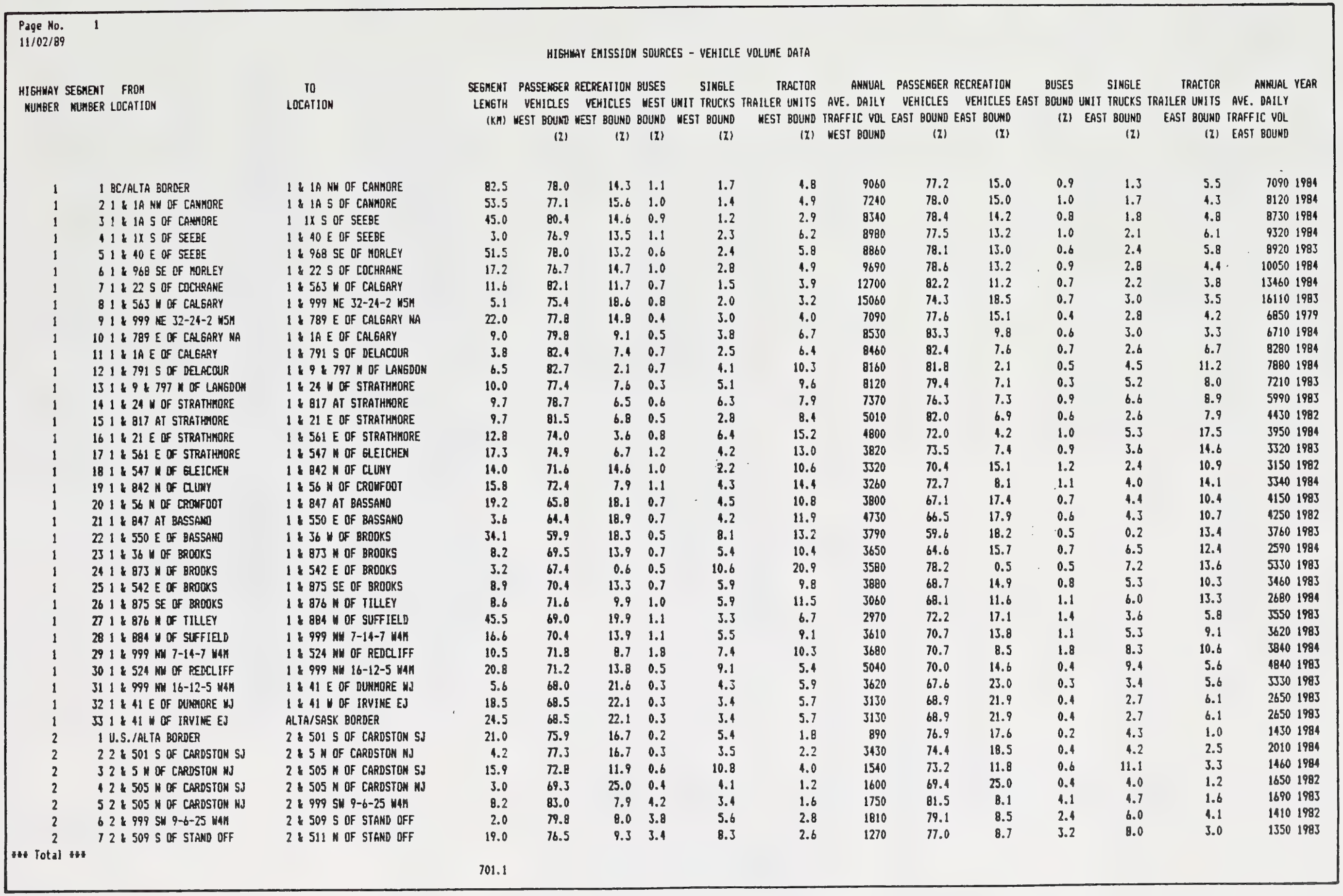
Figure 8F. Sample report: Highway Emission Sources - Basic NO_x Emission Data.



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                                                                         HIGHWAY EMISSION SOURCES - VEHICLE VOLUME DATA

HIGHWAY SEGMENT   FROM                 TO                        SEGMENT PASSENGER RECREATION BUSES      SINGLE       TRACTOR      ANNUAL  PASSENGER RECREATION     BUSES      SINGLE       TRACTOR      ANNUAL YEAR
 NUMBER  NUMBER LOCATION               LOCATION                   LENGTH   VEHICLES   VEHICLES  WEST UNIT TRUCKS TRAILER UNITS  AVE. DAILY   VEHICLES   VEHICLES EAST BOUND UNIT TRUCKS TRAILER UNITS  AVE. DAILY
                                                                    (KM) WEST BOUND WEST BOUND BOUND  WEST BOUND    WEST BOUND TRAFFIC VOL EAST BOUND EAST BOUND       (%)  EAST BOUND    EAST BOUND TRAFFIC VOL
                                                                                (%)        (%)   (%)         (%)           (%)  WEST BOUND        (%)        (%)                   (%)           (%)  EAST BOUND


   1      1 BC/ALTA BORDER             1 & 1A NW OF CANMORE         82.5       78.0       14.3   1.1         1.7           4.8        9060       77.2       15.0       0.9         1.3           5.5        7090 1984
   1      2 1 & 1A NW OF CANMORE       1 & 1A S OF CANMORE          53.5       77.1       15.6   1.0         1.4           4.9        7240       78.0       15.0       1.0         1.7           4.3        8120 1984
   1      3 1 & 1A S OF CANMORE        1  1X S OF SEEBE             45.0       80.4       14.6   0.9         1.2           2.9        8340       78.4       14.2       0.8         1.8           4.8        8730 1984
   1      4 1 & 1X S OF SEEBE          1 & 40 E OF SEEBE             3.0       76.9       13.5   1.1         2.3           6.2        8980       77.5       13.2       1.0         2.1           6.1        9320 1984
   1      5 1 & 40 E OF SEEBE          1 & 968 SE OF MORLEY         51.5       78.0       13.2   0.6         2.4           5.8        8860       78.1       13.0       0.6         2.4           5.8        8920 1983
   1      6 1 & 968 SE OF MORLEY       1 & 22 S OF COCHRANE         17.2       76.7       14.7   1.0         2.8           4.9        9690       78.6       13.2       0.9         2.8           4.4       10050 1984
   1      7 1 & 22 S OF COCHRANE       1 & 563 W OF CALGARY         11.6       82.1       11.7   0.7         1.5           3.9       12700       82.2       11.2       0.7         2.2           3.8       13460 1984
   1      8 1 & 563 W OF CALGARY       1 & 999 NE 32-24-2 W5M        5.1       75.4       18.6   0.8         2.0           3.2       15060       74.3       18.5       0.7         3.0           3.5       16110 1983
   1      9 1 & 999 NE 32-24-2 W5M     1 & 789 E OF CALGARY NA      22.0       77.8       14.8   0.4         3.0           4.0        7090       77.6       15.1       0.4         2.8           4.2        6850 1979
   1     10 1 & 789 E OF CALGARY NA    1 & 1A E OF CALGARY           9.0       79.8        9.1   0.5         3.8           6.7        8530       83.3        9.8       0.6         3.0           3.3        6710 1984
   1     11 1 & 1A E OF CALGARY        1 & 791 S OF DELACOUR         3.8       82.4        7.4   0.7         2.5           6.4        8460       82.4        7.6       0.7         2.6           6.7        8280 1984
   1     12 1 & 791 S OF DELACOUR      1 & 9 & 797 N OF LANGDON      6.5       82.7        2.1   0.7         4.1          10.3        8160       81.8        2.1       0.5         4.5          11.2        7880 1984
   1     13 1 & 9 & 797 N OF LANGDON   1 & 24 W OF STRATHMORE       10.0       77.4        7.6   0.3         5.1           9.6        8120       79.4        7.1       0.3         5.2           8.0        7210 1983
   1     14 1 & 24 W OF STRATHMORE     1 & 817 AT STRATHMORE         9.7       78.7        6.5   0.6         6.3           7.9        7370       76.3        7.3       0.9         6.6           8.9        5990 1983
   1     15 1 & 817 AT STRATHMORE      1 & 21 E OF STRATHMORE        9.7       81.5        6.8   0.5         2.8           8.4        5010       82.0        6.9       0.6         2.6           7.9        4430 1982
   1     16 1 & 21 E OF STRATHMORE     1 & 561 E OF STRATHMORE      12.8       74.0        3.6   0.8         6.4          15.2        4800       72.0        4.2       1.0         5.3          17.5        3950 1984
   1     17 1 & 561 E OF STRATHMORE    1 & 547 N OF GLEICHEN        17.3       74.9        6.7   1.2         4.2          13.0        3820       73.5        7.4       0.9         3.6          14.6        3320 1983
   1     18 1 & 547 N OF GLEICHEN      1 & 842 N OF CLUNY           14.0       71.6       14.6   1.0         2.2          10.6        3320       70.4       15.1       1.2         2.4          10.9        3150 1982
   1     19 1 & 842 N OF CLUNY         1 & 56 N OF CROWFOOT         15.8       72.4        7.9   1.1         4.3          14.4        3260       72.7        8.1       1.1         4.0          14.1        3340 1984
   1     20 1 & 56 N OF CROWFOOT       1 & 847 AT BASSANO           19.2       65.8       18.1   0.7         4.5          10.8        3800       67.1       17.4       0.7         4.4          10.4        4150 1983
   1     21 1 & 847 AT BASSANO         1 & 550 E OF BASSANO          3.6       64.4       18.9   0.7         4.2          11.9        4730       66.5       17.9       0.6         4.3          10.7        4250 1982
   1     22 1 & 550 E OF BASSANO       1 & 36 W OF BROOKS           34.1       59.9       18.3   0.5         8.1          13.2        3790       59.6       18.2       0.5         0.2          13.4        3760 1983
   1     23 1 & 36 W OF BROOKS         1 & 873 N OF BROOKS           8.2       69.5       13.9   0.7         5.4          10.4        3650       64.6       15.7       0.7         6.5          12.4        2590 1984
   1     24 1 & 873 N OF BROOKS        1 & 542 E OF BROOKS           3.2       67.4        0.6   0.5        10.6          20.9        3580       78.2        0.5       0.5         7.2          13.6        5330 1983
   1     25 1 & 542 E OF BROOKS        1 & 875 SE OF BROOKS          8.9       70.4       13.3   0.7         5.9           9.8        3880       68.7       14.9       0.8         5.3          10.3        3460 1983
   1     26 1 & 875 SE OF BROOKS       1 & 876 N OF TILLEY           8.6       71.6        9.9   1.0         5.9          11.5        3060       68.1       11.6       1.1         6.0          13.3        2680 1984
   1     27 1 & 876 N OF TILLEY        1 & 884 W OF SUFFIELD        45.5       69.0       19.9   1.1         3.3           6.7        2970       72.2       17.1       1.4         3.6           5.8        3550 1983
   1     28 1 & 884 W OF SUFFIELD      1 & 999 NW 7-14-7 W4M        16.6       70.4       13.9   1.1         5.5           9.1        3610       70.7       13.8       1.1         5.3           9.1        3620 1983
   1     29 1 & 999 NW 7-14-7 W4M      1 & 524 NW OF REDCLIFF       10.5       71.8        8.7   1.8         7.4          10.3        3680       70.7        8.5       1.8         8.3          10.6        3840 1984
   1     30 1 & 524 NW OF REDCLIFF     1 & 999 NW 16-12-5 W4M       20.8       71.2       13.8   0.5         9.1           5.4        5040       70.0       14.6       0.4         9.4           5.6        4840 1983
   1     31 1 & 999 NW 16-12-5 W4M     1 & 41 E OF DUNMORE WJ        5.6       68.0       21.6   0.3         4.3           5.9        3620       67.6       23.0       0.3         3.4           5.6        3330 1983
   1     32 1 & 41 E OF DUNMORE WJ     1 & 41 W OF IRVINE EJ        18.5       68.5       22.1   0.3         3.4           5.7        3130       68.9       21.9       0.4         2.7           6.1        2650 1983
   1     33 1 & 41 W OF IRVINE EJ      ALTA/SASK BORDER             24.5       68.5       22.1   0.3         3.4           5.7        3130       68.9       21.9       0.4         2.7           6.1        2650 1983
   2      1 U.S./ALTA BORDER           2 & 501 S OF CARDSTON SJ     21.0       75.9       16.7   0.2         5.4           1.8         890       76.9       17.6       0.2         4.3           1.0        1430 1984
   2      2 2 & 501 S OF CARDSTON SJ   2 & 5 N OF CARDSTON NJ        4.2       77.3       16.7   0.3         3.5           2.2        3430       74.4       18.5       0.4         4.2           2.5        2010 1984
   2      3 2 & 5 N OF CARDSTON NJ     2 & 505 N OF CARDSTON SJ     15.9       72.8       11.9   0.6        10.8           4.0        1540       73.2       11.8       0.6        11.1           3.3        1460 1984
   2      4 2 & 505 N OF CARDSTON SJ   2 & 505 N OF CARDSTON NJ      3.0       69.3       25.0   0.4         4.1           1.2        1600       69.4       25.0       0.4         4.0           1.2        1650 1982
   2      5 2 & 505 N OF CARDSTON NJ   2 & 999 SW 9-6-25 W4M         8.2       83.0        7.9   4.2         3.4           1.6        1750       81.5        8.1       4.1         4.7           1.6        1690 1983
   2      6 2 & 999 SW 9-6-25 W4M      2 & 509 S OF STAND OFF        2.0       79.8        8.0   3.8         5.6           2.8        1810       79.1        8.5       2.4         6.0           4.1        1410 1982
   2      7 2 & 509 S OF STAND OFF     2 & 511 N OF STAND OFF       19.0       76.5        9.3   3.4         8.3           2.6        1270       77.0        8.7       3.2         8.0           3.0        1350 1983
*** Total ***

                                                                   701.1
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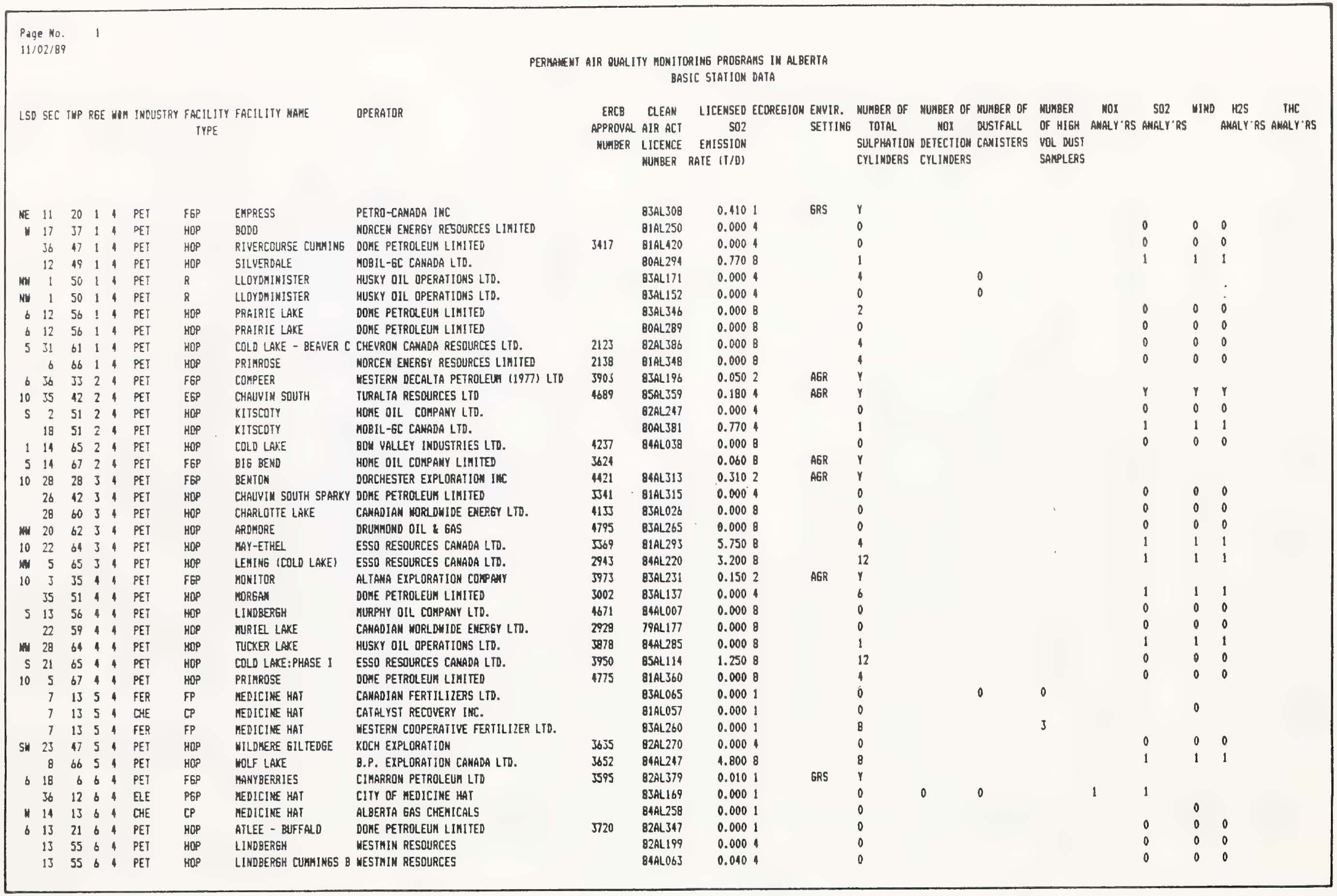
Figure 8G. Sample report: Highway Emission Sources - Vehicle Volume Data.



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PERMANENT AIR QUALITY MONITORING PROGRAMS IN ALBERTA
BASIC STATION DATA

LSD	SEC	TWP	RGE	W#M	INDUSTRY	FACILITY TYPE	FACILITY NAME	OPERATOR	ERCB APPROVAL NUMBER	CLEAN AIR ACT LICENCE NUMBER	LICENSED SO2 EMISSION RATE (T/D)	ECOREGION	ENVIR. SETTING	NUMBER OF TOTAL SULPHATION CYLINDERS	NUMBER OF NOX DETECTION CYLINDERS	NUMBER OF DUSTFALL CANISTERS	NUMBER OF HIGH VOL DUST SAMPLERS	NOX ANALY'RS	SO2 ANALY'RS	WIND	H2S ANALY'RS	THC ANALY'RS
NE	11	20	1	4	PET	FGP	EMPRESS	PETRO-CANADA INC		83AL308	0.410	1	GRS	Y								
W	17	37	1	4	PET	HOP	BODO	NORCEN ENERGY RESOURCES LIMITED		81AL250	0.000	4		0					0	0	0	
	36	47	1	4	PET	HOP	RIVERCOURSE CUMMING	DOME PETROLEUM LIMITED	3417	81AL420	0.000	4		0					0	0	0	
	12	49	1	4	PET	HOP	SILVERDALE	MOBIL-GC CANADA LTD.		80AL294	0.770	8		1					1	1	1	
NW	1	50	1	4	PET	R	LLOYDMINISTER	HUSKY OIL OPERATIONS LTD.		83AL171	0.000	4		4		0						
NW	1	50	1	4	PET	R	LLOYDMINISTER	HUSKY OIL OPERATIONS LTD.		83AL152	0.000	4		0		0						
6	12	56	1	4	PET	HOP	PRAIRIE LAKE	DOME PETROLEUM LIMITED		83AL346	0.000	8		2					0	0	0	
6	12	56	1	4	PET	HOP	PRAIRIE LAKE	DOME PETROLEUM LIMITED		80AL289	0.000	8		0					0	0	0	
5	31	61	1	4	PET	HOP	COLD LAKE - BEAVER C	CHEVRON CANADA RESOURCES LTD.	2123	82AL386	0.000	8		4					0	0	0	
	6	66	1	4	PET	HOP	PRIMROSE	NORCEN ENERGY RESOURCES LIMITED	2138	81AL348	0.000	8		4					0	0	0	
6	36	33	2	4	PET	FGP	COMPEER	WESTERN DECALTA PETROLEUM (1977) LTD	3903	83AL196	0.050	2	AGR	Y								
10	35	42	2	4	PET	EGP	CHAUVIN SOUTH	TURALTA RESOURCES LTD	4689	85AL359	0.180	4	AGR	Y					Y	Y	Y	
S	2	51	2	4	PET	HOP	KITSCOTY	HOME OIL COMPANY LTD.		82AL247	0.000	4		0					0	0	0	
	18	51	2	4	PET	HOP	KITSCOTY	MOBIL-GC CANADA LTD.		80AL381	0.770	4		1					1	1	1	
1	14	65	2	4	PET	HOP	COLD LAKE	BOW VALLEY INDUSTRIES LTD.	4237	84AL038	0.000	8		0					0	0	0	
5	14	67	2	4	PET	FGP	BIG BEND	HOME OIL COMPANY LIMITED	3624		0.060	8	AGR	Y								
10	28	28	3	4	PET	FGP	BENTON	DORCHESTER EXPLORATION INC	4421	84AL313	0.310	2	AGR	Y								
	26	42	3	4	PET	HOP	CHAUVIN SOUTH SPARKY	DOME PETROLEUM LIMITED	3341	81AL315	0.000	4		0					0	0	0	
	28	60	3	4	PET	HOP	CHARLOTTE LAKE	CANADIAN WORLDWIDE ENERGY LTD.	4133	83AL026	0.000	8		0					0	0	0	
NW	20	62	3	4	PET	HOP	ARDMORE	DRUMMOND OIL & GAS	4795	83AL265	0.000	8		0					0	0	0	
10	22	64	3	4	PET	HOP	MAY-ETHEL	ESSO RESOURCES CANADA LTD.	3369	81AL293	5.750	8		4					1	1	1	
NW	5	65	3	4	PET	HOP	LEMING (COLD LAKE)	ESSO RESOURCES CANADA LTD.	2943	84AL220	3.200	8		12					1	1	1	
10	3	35	4	4	PET	FGP	MONITOR	ALTANA EXPLORATION COMPANY	3973	83AL231	0.150	2	AGR	Y								
	35	51	4	4	PET	HOP	MORGAN	DOME PETROLEUM LIMITED	3002	83AL137	0.000	4		6					1	1	1	
5	13	56	4	4	PET	HOP	LINDBERGH	MURPHY OIL COMPANY LTD.	4671	84AL007	0.000	8		0					0	0	0	
	22	59	4	4	PET	HOP	MURIEL LAKE	CANADIAN WORLDWIDE ENERGY LTD.	2928	79AL177	0.000	8		0					0	0	0	
NW	28	64	4	4	PET	HOP	TUCKER LAKE	HUSKY OIL OPERATIONS LTD.	3878	84AL285	0.000	8		1					1	1	1	
S	21	65	4	4	PET	HOP	COLD LAKE:PHASE I	ESSO RESOURCES CANADA LTD.	3950	85AL114	1.250	8		12					0	0	0	
10	5	67	4	4	PET	HOP	PRIMROSE	DOME PETROLEUM LIMITED	4775	81AL360	0.000	8		4					0	0	0	
	7	13	5	4	FER	FP	MEDICINE HAT	CANADIAN FERTILIZERS LTD.		83AL065	0.000	1		0		0	0					
	7	13	5	4	CHE	CP	MEDICINE HAT	CATALYST RECOVERY INC.		81AL057	0.000	1		0						0		
	7	13	5	4	FER	FP	MEDICINE HAT	WESTERN COOPERATIVE FERTILIZER LTD.		83AL260	0.000	1		8			3					
SW	23	47	5	4	PET	HOP	WILDMERE GILTEDGE	KOCH EXPLORATION	3635	82AL270	0.000	4		0					0	0	0	
	8	66	5	4	PET	HOP	WOLF LAKE	B.P. EXPLORATION CANADA LTD.	3652	84AL247	4.800	8		8					1	1	1	
6	18	6	6	4	PET	FGP	MANYBERRIES	CIMARRON PETROLEUM LTD	3595	82AL379	0.010	1	GRS	Y								
	36	12	6	4	ELE	PGP	MEDICINE HAT	CITY OF MEDICINE HAT		83AL169	0.000	1		0	0	0		1	1			
W	14	13	6	4	CHE	CP	MEDICINE HAT	ALBERTA GAS CHEMICALS		84AL258	0.000	1		0						0		
6	13	21	6	4	PET	HOP	ATLEE - BUFFALO	DOME PETROLEUM LIMITED	3720	82AL347	0.000	1		0					0	0	0	
	13	55	6	4	PET	HOP	LINDBERGH	WESTMIN RESOURCES		82AL199	0.000	4		0					0	0	0	
	13	55	6	4	PET	HOP	LINDBERGH CUMMINGS B	WESTMIN RESOURCES		84AL063	0.040	4		0					0	0	0	

Figure 8H. Sample report: Permanent Air Quality Monitoring Programs in Alberta - Basic Station Data.

Due to the large amount of mass storage required (i.e., approximately 1.5 megabytes), only microcomputers with a hard disc drive will have sufficient memory to accommodate the developed inventories. For the purpose of the following discussion, it is assumed that AAESI and the inventories are loaded on the hard disc in a subdirectory named "C:/DBASE".

In order to utilize the developed inventories and AAESI, the user must have a copy of the Ashton•Tate database management system, dBASE III. This system is available through most microcomputer software dealers.

The basic instructions for operation of AAESI are as follows:

1. Enter the dBASE III environment - dBASE III is a copy protected program and therefore must be booted off the dBASE III system disk. Insert the system disk into the floppy drive, set access to that drive (i.e., for drive A enter the command [A:]*) and enter the command [DBASE]. The dBASE III logon message and dot prompt should appear.
2. Set default access to the hard disc - Enter [SET PATH TO C:/DBASE].
3. Activate AAESI - Enter [DO AAESI]. Once AAESI has been activated, the user may perform a variety of data management tasks by simply responding to the menu selections which appear on the screen.
4. Exit dBASE III - Once the user has exited AAESI and is ready to leave the dBASE III environment, enter [QUIT].

For those users who wish to work outside of AAESI it is appropriate to identify the database in which each of the inventories is stored. This is done in Table 19.

For general use of the dBASE III database management system, the reader is referred to the dBASE III user's manual.

5.3 QUALITY ASSURANCE MEASURES

To provide quality assurance of the computerized inventories, a number of quality control measures were implemented and checks of the data performed. These measures and checks consisted of the following.

1. The screen of the video display terminal was specially formatted to:
   - provide easy entry of data into the computer memory,
   - prevent numeric data from exceeding specified ranges, and
   - prevent character entry into numeric fields.
2. All character fields were sorted alphabetically and subsequently checked for spelling errors and omissions.
3. A check for duplication of facilities and duplication of emission sources at each facility was performed.

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* The information to be typed is that contained within the brackets. Do not type the brackets, themselves. After a command has been typed, press the return, or enter, key.

Table 19. Names of the computer files in which the developed inventories are stored.

Description	dBASE III File Name[1]
SO_2 Emissions	SO2_STK.DBF
NOx Emissions	
- Stack Sources	NOX_STK.DBF
- Urban Sources	URB.DBF
- Highway Sources	HYW.DBF
Air Quality Monitoring Stations	AQM.DBF

[1] A dBASE III file name may consist of up to eight characters, not including the file identifier (i.e., "•DBF" for database files), must begin with a letter, may contain numeric characters, and may include embedded underscore characters (i.e., "_"). dBASE III file names may not include any embedded blank spaces.

4. A check was performed to ensure that all NOx and SO_2 emission sources identified in the Alberta Environment inventories (1984 and 1985) were included.
5. A listing of all sour-gas processing plants in the province was obtained from ERCB and a check was performed to ensure that these plants were included in the SO_2 inventory.
6. A comparison of predicted and licenced emissions was performed to help identify errors in these two data fields. If, for a given case, the predicted values were greater than the licenced values, both data were verified.
7. A hard copy of each inventory was produced and, subsequently, inspected for anomalies.

6. REFERENCES CITED

Alberta Environment, Pollution Control Division. 1984. Nitrogen Oxides Emissions for Alberta, 1978-1982. Edmonton, Alberta. 21 pp.

Alberta Environment, Pollution Control Division. 1985. Industrial Sulphur Emissions Inventory, 1979-83. Draft Copy. Edmonton, Alberta. 23 pp.

Alberta Municipal Affairs, Municipal Administrative Services Division. 1985. Official Population List. Edmonton, Alberta.

Alberta Transportation, Systems Planning Branch, Traffic Information Services. 1985. Traffic Volume Breakdown on Primary, Secondary and Other Roads. Edmonton, Alberta.

Baumeister, T., E.A. Avallone, and T. Baumeister. 1978. Mark's Standard Handbook for Mechanical Engineers, 8th ed. McGraw-Hill: Toronto, Ontario. 12.71 pp.

Colley, D.G., E.M. Berlie, and M.J. Zelensky. 1982. Flaring Versus Thermal Incineration of Waste Gases in the Oil and Gas Industry. Presented at Pacific North-West International Section, Air Pollution Control Association, Annual General Meeting. November 15-17, 1982. Vancouver, British Columbia. 20 pp.

Dibbs, H.P. and P. Marier. 1973. Methods for the Removal of Sulphur from Coal. Engineering Division, Technology Development Branch, Air Pollution Control Directorate. Ottawa, Ontario. Report EPS 3-AP-73-3. 59 pp.

Energy Resources Conservation Board. 1985a. Alberta Electric Industry, Annual Statistics. Calgary, Alberta. ERCB Report ST 85-25. 33 pp.

Energy Resources Conservation Board. 1985b. Alberta Gas Plant Statistics to December 31. Calgary, Alberta. ERCB Report ST 85-13A.

Energy Resources Conservation Board. 1985c. Alberta Oil and Gas Industry, Annual Statistics. Calgary, Alberta. ERCB Report ST 85-17. 95 pp.

Energy Resources Conservation Board. 1985d. Alberta Oil Sands, Annual Statistics. Calgary, Alberta. ERCB Report ST 85-43. 27 pp.

Environment Canada, Atmospheric Environment Service. 1981. Climatological Station Data Catalogue, Prairie Provinces. Downsview, Ontario. 164 pp.

Environment Canada, Atmospheric Environment Service. 1982. Canadian Climate Normals, Volume 2 - Temperature 1951-1980. A Publication of the Canadian Climate Program. Downsview, Ontario. 306 pp.

Environment Canada, Environmental Protection Service. 1985. Letter from Jonah A. Libman, Special Projects Office, Transportation System Division, Ottawa, Ontario.

Hansen, M.C. and M.D. Jones. 1982. An Assessment of Collection and Handling of Climate Data by Alberta Government Agencies. Prep. for Alberta Environment, Research Management Division, by Western Research, Division of Bow Valley Resource Services Ltd. Edmonton, Alberta. RMD Report 82/12.1. 45 pp.

Leahey, D.M., H.G. Paskall, M.B. Schroeder, and M.J. Zelensky. 1985. A Preliminary Study of the Composition and Combustion Efficiency of a Sour Gas Flare. Prep. for Alberta Environment, Research Management Division by Western Research, Division of Bow Valley Resource Services Ltd. Calgary, Alberta. RMD Report 85/30. 93 pp.

Legge, A.H. and B.L. Baker. 1987. The Effects of Nitrogen Oxides on Native Vegetation Near Compressor Installations in Alberta. Part III: Compressor Installations in Alberta. Prepared for Alberta Environment, Research Management Division by the Kananaskis Centre for Environmental Research, The University of Calgary. Edmonton, Alberta. Research Management Division RMD Report 87/43 (III). 197 pp. (in press).

PEDCO - Environmental Specialists, Inc. 1974. Source Inventory and Emission Factor Analysis, Volume I. Prep. for U.S. Environmental Protection Agency. NTIS: Research Triangle Park, North Carolina. Report PB 247 743.

Perry, R.H. and C.H. Chilton. 1973. Chemical Engineers Handbook, 5th ed. McGraw-Hill: Toronto, Ontario. 24:14 pp.

Strong, W.L. and K.R. Leggat. 1981. Ecoregions of Alberta. Alberta Resource Evaluation and Planning Division, Energy and Natural Resources. Edmonton, Alberta. 64 pp.

Subcommittee on Biophysical Land Classification. 1969. (Compiled and edited by D.S. Lacate). Guidelines for Biophycial Land Classification. Canada Department of Fisheries and Forestry. Forestry Services Publication 1264. 55 pp. (Original not seen, information taken from Strong and Leggat, 1981).

U.S. Environmental Protection Agency. 1985. Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources. 4th ed. Available through NTIS. Springfield, Virginia. Report PB86-124906.

Western Research and Development Ltd. 1976a. An Application of an Air Pollution Model to the City of Calgary. Prep. for Alberta Department of the Environment. Edmonton, Alberta. 33 pp.

Western Research and Development Ltd. 1976b. An Application of an Air Pollution Model to the City of Edmonton. Prep. for Alberta Department of the Environment. Edmonton, Alberta. 60 pp.

Zelensky, M.J. 1983. NOx Control Technology for Compressor Engines in Alberta. A Report Prepared Under the Auspices of the Alberta Government/Industry Acid Deposition Research Program by Western Research Division of Bow Valley Resource Services Limited. 89 pp.

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